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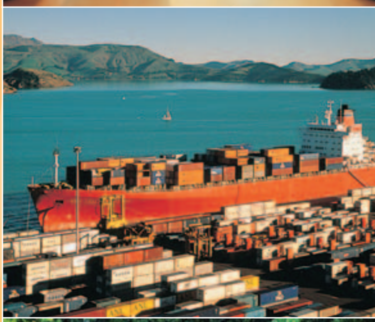
The Socio-technical Networks of Technology Users' Innovation in New Zealand: A Fuzzy-set Qualitative Comparative Analysis



Simon J. Lambert
John R. Fairweather

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Acknowledgements

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We also acknowledge the valuable assistance of the inventors who provided the core material for study. They are an impressive group of Kiwi inventors and their willingness to share their experiences made for rich and useful data. Diane Barraclough from IPONZ provided insight and assistance in IP, as did Elspeth Buchanan (PL Berry and Associates) and Donald Ensor (Ensor and Associates). Tony Smale (eNZyme intellect) helped with our understanding of the New Zealand context.

Preface

The topic of innovation is particularly popular at the present time, attracting the attention of a wide variety of people including key policy makers in many countries. In parallel to this interest is a focus on innovation to the extent that Innovation Studies is a specialist area in its own right, embracing a number of traditional disciplines.

Research work in the AERU has covered innovation in a number of ways for many years. This report continues this tradition but, in addition, provides an analysis of success factors among New Zealand inventors seeking to commercialise their ideas. Here the focus is on technology users who innovate, with this report being one of the key outputs of the Networks and Innovation Governance research programme. The focus on inventors is important because they are often overshadowed by innovation in universities and research institutes; it also offers ways to consider how best to understand and support this form of innovation.

This report should appeal to those interested in what inventors think about the invention and commercialisation process. It would also appeal to policymakers wanting to know how best to support inventors.

Prof. Caroline Saunders
Director

Summary

Technological innovation by the actual users of technologies is receiving more attention, and deservedly so, as these users combine their passions and expertise into improving the technologies which they employ in their personal and professional lives. This report documents technology users' innovation (TUI) as an important source of inventions which can become successful commercial innovations. Using a range of TUI case studies in the farming, building and energy sectors, we utilise fuzzy-set Qualitative Comparative Analysis (fsQCA) to describe configurations of participation in various network configurations that result in innovation success and failure. Data are drawn from extended interviews with over 55 inventors and innovators, leading to 43 final case studies set against a broader analysis of New Zealand's innovation policies and practice. The method led to the identification of five key elements within the socio-technical networks of innovation: financial capital, government support, intellectual property (IP), manufacturing, and other business activities.

Results show the key configurations to innovation success involve inventors who were:

- Well financed, not undertaking significant manufacturing, holding relevant IP; or,
- Well financed, engaged in other businesses, again with relevant IP.

The most common configurations leading to innovation failure were:

- Poorly financed, lacking government support, not engaged in other business activities, and lacking IP; or,
- Well financed, lacking government support, engaged in other businesses, undertaking significant manufacturing, and lacking IP.

The results were used to develop a model of TUI which shows how innovation is the product of both individual inventive ability and the ability to selectively participate in the relevant socio-technical networks within which the invention evolves into an innovation. A significant resource on which these innovators draw is best understood as social capital, comprising family farm(s) and firm(s), family members, and peers. The model highlights the potential complexity of the TUI networks and shows how successful innovation requires the release of an often intensely personal technology and through the proactive management of the key factors.

The results also indicate that New Zealand's innovation governance could be improved by policy which better supports TUI, specifically by increasing and facilitating the availability of financial capital and IP protection, expanding and supporting international collaboration (especially in offshore manufacturing), and addressing ethics and trust in business. Wider societal issues also constrain innovation in New Zealand. These issues would be mitigated by an increase in the technological literacy of New Zealand society as well as a wider and deeper appreciation of the necessity and difficulty of innovation, and the personal and economic rewards when it succeeds. While much of the success of local TUI stems from the character of New Zealanders, their knowledge and their passions, that success would be enhanced by improving the connectivity of the New Zealand innovation system as a whole, and the connectivity of this system globally.

Keywords: QCA, fuzzy-set QCA, invention, innovation; technology users; networks; social capital; New Zealand.

Chapter 1
A Network Approach to Technology Users' Innovation (TUI)

1.1 Introduction: innovation within a social network

'Innovate or die' seems to be the harsh but proverbial motto of firms, regions, multinational corporations and states. While innovation can, and does, occur across all areas of society, the debate is dominated by technological innovation and its economic value. Yet in attempting to observe and explain technological innovation, our attention is quickly drawn to the array of spheres involved. Indeed, the sheer pace and scale of such innovation has meant that people now experience some technologies as a somewhat 'alien and uncanny force', despite being intentionally and systematically put in place (Rapp, 1981, p. 2).

But technological innovation is vital for economic growth and is therefore debated, measured, theorised, and subjected to contested policy processes. Typically, such innovations have been thought to derive from formal research and development organisations. However, an important alternative source is from uniquely creative individual inventors. Popular myth in New Zealand sees many significant innovations derived from these individuals, reinforcing important parts of national culture and identity such as rugged individualism and success against the odds. While these accomplishments are significant to New Zealanders, and undoubtedly many other societies, we argue that it is the social networks of these individuals that are important and while inventiveness is a necessary condition for success, it is certainly not sufficient.

While the New Zealand economy has struggled to maintain its previously high socio-economic rankings (Drew, 2007; OECD, 2009), even if pertinent macro-economic indicators were in some way satisfactory, the pressure to innovate at all levels of the economy would not cease. Indeed the term 'innovation' now appears as a global synonym for 'economic growth', 'productivity' 'development', even 'sustainability'. In New Zealand successive governments accepted technological progress as 'the only sustainable way to a nation's long-term productivity growth', which is considered 'essential' for long-term international competitiveness (Williams, Debski, & White, 2008, p. 2).[1]

While coarse indicators, or rather the forces underlying them, build our understanding of innovation, inventions have also originated from beyond the reach of these macro-level proxies, or at least from outside formal organisations such as universities, research organisations and large corporate entities. Small-scale firms and individuals with an intimate material and social association with a particular technology, and often without formal qualifications, professional research networks or funding, have produced significant innovations. Indeed New Zealand's modern mythology is replete with innovators as heroes: Sir Ernest Rutherford, a small-town boy who went on to split the atom; Sir Edmund Hillary, the conqueror of Everest who went on to drive a (modified) tractor to the South Pole and jet boat down the Ganges; Bill Hamilton who invented the jet boat; Bill Gallagher, a Waikato farmer who developed electric fencing; A.J. Hackett, who made millions from jumping off tall structures tethered with elastic and so on. Indeed, it is the inventiveness of farmers such as

[1] Such a discourse provides its own indicators such as business expenditure on research and development (BERD), which is 0.49 per cent of GDP in New Zealand compared with an OECD average of 1.53 per cent. Other proxies, often labelled science and technology indicators (STI), are R&D budget allocations, the number of PhDs (particularly in science and engineering field) and the number of patents and bibliometric citations (Gluckman, 2009; Godin, 2003; see also Smith, 2005).

Gallagher and self-taught engineers such as Hamilton that epitomise the 'end-user innovation' (von Hippel, 1988) that is colloquially described in New Zealand as 'back shed' and 'number 8' wire Kiwi ingenuity.[2]

This romanticism is in one sense comforting for New Zealanders – we have the history and cultural resources to innovate – yet is at best an inadequate account of what is occurring, and at worst a quite misleading one. Rutherford was ensconced within one of the world's great research institutions with three Nobel prize winners (including himself) on staff and with several hundred students, the best of which undertook the menial tasks of experimentation (Cathcart, 2004). Similarly, Bill Gallagher, heartland farmer, incorporated ideas from America and went on to head the Gallagher Group which now employs its own engineers and holds over 500 patents (Gallagher Group, 2008; Intellectual Property Office of New Zealand, 2009). Hamilton attended a preparatory school and then one of the best private colleges in the country, and travelled more than once to England where he entered and won several motor races (Hamilton Jet, 2009). Ed Hillary's diverse activities were successful in part because he became quite adept at cajoling support and funding from influential sources. Our rugged individualists turn out to be rather adept social players.

This study focuses on three key sectors for New Zealand development – farming, building, and energy – that are also globally relevant. Our research is informed by Science and Technology Studies (STS) approaches to bridge the gap between the technological determinism paradigm, which assumes research and development (R&D) propels innovation, and the social science tendency to avoid technological determinism (Sismondo, 2004). Technologies and innovation are continually present, sometimes intimate and yet always malleable expressions of society, a discourse which accepts the inextricable *sociality* of things. In the words of MacKenzie and Wajcman (1999, p. xiv):

> *"We live our lives in a world of things that people have made. As human beings, we have both relations to each other (…society) and also relations to the things we have made and to our knowledge of these things … technology."*

In effect, all technologies occur within a social network and it is the management of these **socio-technical networks** that is important for innovators, policy makers, and society. We argue that inventors selectively participate in the socio-technical networks relevant to their particular efforts at innovation. We further argue that such selective involvement in financial capital, government support, IP and so on can be measured, with membership scored according to criteria emerging from both theory and the substantive knowledge and understanding accumulated from our case studies.

We use the following key terms which will be elaborated and built on in Chapter 2:

- Technology user: a person who uses any item of technology broadly defined to include both widgets and processes.

[2] There are a number of popular publications displaying and idealising this Kiwi ingenuity. See, for example Hopkins (Hopkins, 1998, 1999, 2002, 2004); also Bridges & Owens (2000) and (Hogan & Williamson, 1999). A bimonthly magazine called 'The Shed' is currently published and portrays examples of the type of invention we focus on (www.theshedmag.co.nz). For an interesting history of science innovation in New Zealand, see Galbreath (1998).

- Innovation: an invention carried through to commercial production and distribution
- TUI: Technology User's Innovation.
- Innovation success: the commercialisation of an invention such that there are significant levels of sales either nationally or internationally.
- Socio-technological networks: interconnections between people and technologies.
- Innovation governance: assemblage of policies, institutions and organisations focused on innovation.

This report contributes a new method for describing and understanding innovation by using **Fuzzy-set Qualitative Comparative Analysis** (fsQCA) to analyse case studies of invention according to their participation in, or membership of, networks. Importantly, fsQCA can incorporate both qualitative and quantitative data and accepts that causation will be configurational (i.e., more than one factor will be involved) and that more than one configuration may exist (Ragin, 2000; C Ragin, 2008; Rihoux & Ragin, 2009).

1.2 Problematic level of innovation in New Zealand

Having introduced the case for giving attention to what we term socio-technical networks in which important innovation occurs, we now need to take a step back and consider the state of innovation in New Zealand. New Zealand is an open but physically isolated neoliberal economy of just over four million citizens, reliant on primary exports, especially agricultural products, and tourism.[3] The country has a well-developed education system, high levels of literacy, and enjoys relatively a benign security environment and a very high quality of life for many of its citizens.

But concerns over New Zealand's economic performance are long-standing (Crocombe, Enright, & Porter, 1991; Easton, 1997; Kelsey, 1995; Saunders, Dalziel, & Kaye-Blake, 2009). By standard indicators, the New Zealand economy continues to underperform, and the decline relative to its competitors, especially neighbouring Australia, has not abated.[4] While committed to a model of economic development that accepts technological innovation as vital, the country struggles to match the investment of those countries with which it stand in self-conscious comparison (see Table 1.1).

Business expenditure on R&D also lags internationally, although there are exceptions. Johnston (1991, p. 3) examined the technology strategies of New Zealand firms and found a significant number 'recognised and responded to the challenges presented by deregulation and trade liberalisation'. Though there is a low level of industrial R&D (0.3 per cent of GDP compared to an OECD average of 1.1 per cent), the expenditure of those firms that do engage in significant R&D was comparable to international competitors. Further evidence points to a decline in the number of New Zealand companies, particularly small and medium-sized

[3] Recent Statistics New Zealand data quoted by Proudfoot (2010) show that 66 per cent of New Zealand's merchandise exports derive from agribusiness and food-related products.

[4] According to the OECD (2009: 54) New Zealand GDP per capita was US$27,100 in 2007, 25 per cent below Australia and 12 per cent below the OECD average. Compare this with the early 1970s when New Zealand's real GDP per capita was approximately equal to Australia's and about 15 per cent above the OECD average. From 1970 to 2006 it grew at an average annual rate of only 1.2 per cent, the lowest rate apart from Switzerland among 26 OECD countries with comparable data. New Zealand's relative standard of living fell below the OECD average by the early 1980s and bottomed at 20 per cent below the OECD average in the early 1990s.

companies, being 'fully up-to-date' with the best commonly available technology (see Appendices 13 and 14).

Table 1.1: Gross R&D expenditure as proportion of GDP (selected OECD countries and total)

Country	%
Australia	2.01
Denmark	2.46
Finland	3.45
Ireland	1.32
Norway	1.52
Sweden	3.74
OECD Total	2.26
NZ	1.16

Source: (MoRST, 2008, Table 2:03)

Some studies suggest that innovation may be enhanced if R&D spending were increased (Ministry of Research, 2010). While the current government has initiated a number of reports into, among other things, science and innovation, wider issues such as capital markets (Capital Markets Development Taskforce, 2009) and telecommunications (van Wyk, 2009) have also been identified as significant for innovation. While this may well be the case and we have no issue with such initiatives, we seek to compliment this policy position by considering how innovation may be enhanced by focusing on technology users' innovation (TUI) and the social contexts in which this type of innovation occurs.

1.3 Examples of New Zealand innovation studies that consider context

Our approach is not unprecedented and there are a number of studies that have given explicit consideration to the social context of innovation. Winsley (1997, p. 8) examined technological innovation in New Zealand between 1981 and 1993, a 'dynamic process undertaken within the strategic governance framework of a firm'. He found that human capital and wider social processes were fundamental to technological innovation. Similarly, the New Zealand Innovation Project published a remarkable collection of case studies that give very good descriptions of the socio-cultural context of innovation in Zealand (Gilbertson, Gilbertson, Knight, & Wright, 1995; Gilbertson, Knight, Kukutai, & Cooper, 1992; Winsley, Gilbertson, & Couchman, 2001). Drawing on the experiences of the managers of innovation, and recording rich narratives of business praxis, it seems success occurred despite, and not because, of New Zealand's formal innovation system.

Broader cultural beliefs are also connected to innovation (Henrich, 2001; Hofstede, 1984; Hussler, 2004). Perry (2001) examined the theory that small industrial economies such as the Nordic countries experience trust emanating from shared backgrounds and the likelihood of physical, social and professional proximity, which pressures participants to 'play by the rules' (The Listener, 2010; Yandle, 2010). This proximity and trust are thought to facilitate the flow of information across business communities, with tacit assurances that other members will not take undue advantage while still benefitting from sharing information and other resources. The consequent reduction in risk and costs is undoubtedly conducive for business.

Perry (2001) sought to replicate these findings in New Zealand, surveying business managers and coordinators. Most respondents believed ‘perceived commonality’ makes business cooperation relatively easy to establish, although around two-thirds did not believe that trust existed irrespective of an enduring work experience. In contrast to the Nordic shared trust, ‘mutual experience’ was found to shape the degree of trust amongst New Zealand managers. Interestingly, Perry found the significance of exclusion from a professional group is lower in New Zealand, meaning that breaking trust may bring minimal sanctions. Results also show indicate large companies were disinterested in mutual development opportunities with small firms, and foreign-owned companies were less inclined to cooperate than were locally owned businesses.

Scale and isolation are regular and significant factors in New Zealand’s economic operation (McCann, 2009). Hendy (Hendy, 2009) investigated New Zealand patent distribution, highlighting scale with evidence that innovation as measured by patents per capita increases with city size. Correcting for city size, New Zealand cities perform similarly to Australia and Canada but larger cities will always attract more inventors, drawing in more people, capital and allowing more knowledge spillovers than smaller centres, although Hendy also found many large communities of inventors connected via co-patents.

Important insights have been gathered by Smale (2009) who has identified a connection between the Kiwi approach to the initiation of innovation, in which we have considerable strength, and its subsequent implementation, in which we do not. Interestingly for the purposes of our report, Smale reiterates that the workplace is a primary source of innovation. Smale interprets how New Zealanders negotiate innovation in a global context in which national culture is ‘software for the mind’ that, in the case of New Zealand, tends to limit opportunities.

These few studies illustrate approaches which consider the social context of the innovator. However, they have not made a significant contribution to our understanding of how socio-technical networks directly affect innovation. Accordingly, we turn to more generic social science literature to better understand this topic.

1.4 A network approach to innovation: innovation ecology and social capital

The importance of technological innovation was identified over 150 years ago by Mill (1848) in his *Principles of Political Economy* where he described four fundamental sources of national wealth, namely capital, labour, land and what Mill labelled ‘productiveness’. While economists would better articulate the relationships between these four variables over time, (see, e.g., Romer, 1990), a simplistic linear model of research investment leading to development (the classic R&D model) has only lately been overturned by the identification of complex networks leading to technological innovation and the establishment of a broad church of innovation (Dosi, 1982; Gibbons & Johnston, 1974; Kline & Rosenberg, 1986; Rothwell et al., 1974). As Easton (1997) points out, the ‘arithmetic residual’ of ‘productiveness’ has no *explanatory* ability, indeed has been described as a ‘coefficient of ignorance’ (Balogh and Streetan, 1961, cited in Easton, p. 204). The fundamental flaw was articulated by Dosi (1982) who could not accept that expenditure on R&D somehow results in the prescient production of new goods and services needed by willing consumers. He was equally dismissive of the ‘demand’ or ‘market pull’ interpretation, which meant the existence of an imminent demand, expressed in prices or expectations of future prices, which firms somehow recognise and respond to by developing new goods and services. Dosi theorised the existence of technological paradigms which he defined as the set of procedures for the definition of problems and the specific knowledge of their solution.

In attempting to observe and explain innovation, our focus is quickly challenged by the sheer multitude of actors involved, and the wide-ranging and often unintended effects of many innovations. Not only is technology all-pervasive and both tangible and intangible, but the sheer pace and scale of innovations has meant that although technology is 'intentionally and systematically' put in place, it is increasingly experienced as a somewhat 'alien and uncanny force' (Rapp, 1981). Considerable attention has been given to the study of innovation, which in turn has led to a general acceptance that much of what influences innovation takes place through networks. As Akrich, Callon, & Latour put it:

> *The nuts and bolts of the plot are well known. On the one hand is invention i.e. ideas, projects, plans, and yet also prototypes and pilot factories: in a word, all that occurs prior to the first uncertain meeting with the user and the judgement which he will pass. On the other hand is innovation in the strict sense of the word i.e. the first successful commercial transaction or more generally, the first positive sanction of the user. Between the two extremes is a fate played out in accordance with a mysterious script.… A project deemed to be promising by all of the experts which suddenly flops, while another in which everybody lost faith suddenly transforms itself into a commercial success. And always the same questions: how can these unforeseen successes and failures be explained? How to account for these unexpected turnarounds, these resistances which turn into support or these enthusiasms which change into scepticism and then into rejection?*
>
> (Akrich, Callon, & Latour, 2002)

But the study of the 'mysterious script' of innovation has become more coherent, if no less challenging. As Fagerberg and Verspagen (2009) point out, academia has formalised 'Innovation Studies' and, as with any nascent discipline, there is a rather disparate collection of approaches. Some approaches have coalesced around the methodologies of geography and policy studies (Gertler, 2003; Gertler & Levitte, 2005; Hussler, 2004; Morgan, 2004); others have been moulded by the 'free-wheeling discursive voyages' into capitalism described by Joseph Schumpeter (Backhaus, 2003; Garud & Karnoe, 2003). Beyond this, Smits (2002) notes that innovation is now linked to the emergence of a 'porous society' in which 'knowledge intensive intermediaries' have a fundamental role as they combine the insights and abilities of both users and producers. The term 'ecosystem' is now applied to innovation, further emphasising its complexity (see, e.g., New Zealand Institute, 2009). Metcalfe (2007) usefully distinguishes between **innovation ecologies**, comprised of those people that are the 'repositories and generators of new knowledge', and **innovation systems** or 'connections between the components that ensure the flow of information necessary for innovation to take place' (ibid., p. 448). This extended holistic interpretation of innovation has several antecedents. Wulf (2007) referred to an 'ecology' of innovation, comprising 'interrelated institutions, laws, regulations, and policies providing an innovation infrastructure that entails education, research, tax policy, and intellectual property protection, among others.' Dvir and Pasher (2004) list a number of attributes to innovation ecology, including the time and space to muse; a conducive organisational structure ('flat', with weak boundaries and a low emphasis on hierarchy); tolerance of risk; clear strategies and attention to the future; recognition and incentives; financial capital; human diversity; and conversations – the 'unifying principle'.

The constituent parts of any modern innovation system are now irrevocably spread beyond national borders. Many of the human resources that undertake innovation are highly mobile knowledge migrants. Therefore, given the breadth and salience of innovation, we should not dismiss the possibility of key insights from previously ignored disciplines or indeed from apparently novel and unrelated areas of investigation. Key (2010) in a recent publication *Obliquity: why our goals are best achieved indirectly*, challenges explicit, highly rationalised, goal setting – to be rich as an individual, to be profitable as a company – which may not be as successful as approaching such goals in a less direct manner. Among the things that may indirectly influence innovation, we identify **social capital** as a vital piece of the innovation puzzle, certainly present in our TUI case studies but extending throughout the wider networks of government and private organisations (see also Firkin, 2001; Landry, Amara, & Lamari, 2002; Rutten & Boekema, 2007). There are three components of social capital that have been described (Putnam, 2000; Svendsen & Sorensen, 2007) and that we have recognised in our TUI case studies. They are **bonding capital**, an 'inward-looking' trust and support that takes place within boundaries of exclusivity, such as family ties or ethnic communalism; **bridging capital**, the 'outward-looking' networks that enable individuals and groups to exchange tangible and intangible assets with outsiders; and **organisational capital**, the structures and practices that simple enable 'things to be done'.

New Zealand, as with other countries, has articulated goals of productivity, growth, sustainability and now 'innovation' in increasingly explicitly terms and yet as we see, outcomes have been poor at best and – given the acknowledged importance of such broad goals – somewhat disquieting. Might it be that innovation is best approached indirectly? Is there some way that policy can act in a more oblique manner on the 'unifying principles' of innovation to bring about better outcomes?

In line with these recent developments, we see people who use technology with skill, insight and creative awareness as potent sources of innovation. We outline a conception of their role in what we term **technology users' innovation** in Figure 1.1. To some degree all members of society are technology users. While TUI may be a remarkable subset of society, only some cases may become commercially viable, and at this point the 'back shed' inventor is an innovator.

Figure 1.1: Positioning technology users as innovators

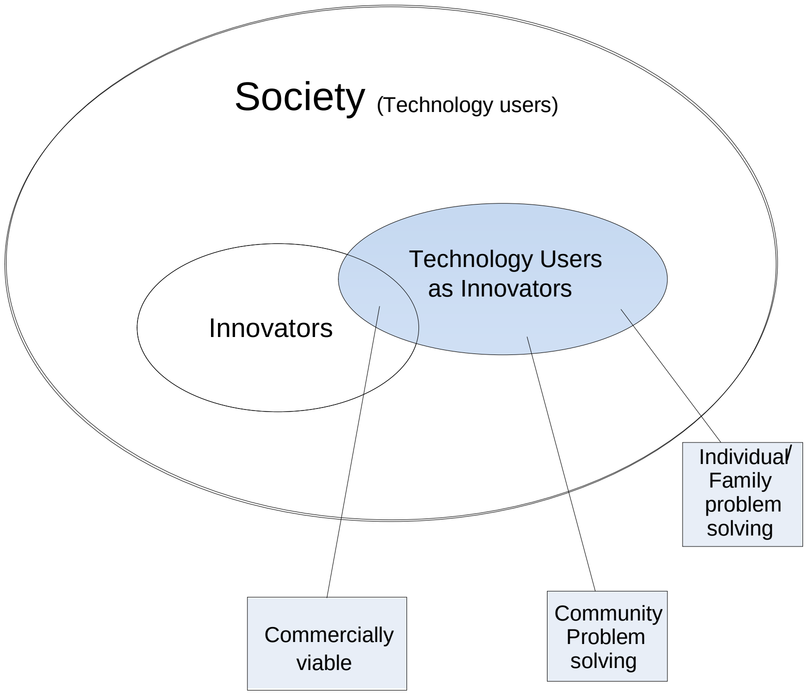


Figure 1.1 places technology users within a context that includes the people who form the social networks of the inventor/innovator (Grabher, Ibert, & Flohr, 2008; von Hippel, 1976, 1988). In these networks can be seen the effects of innovation governance, that is the broad sweep of policy settings and state or private organisations. The TUI voice is often excluded from this discourse. Government innovation surveys generally omit businesses employing fewer than 5 people.[5] We have focused on an interpretation of the relevant networks as socio-technical phenomenon in that we are concerned with how TUI participate in those networks that in some way govern their technology innovation efforts. Examining these networks will provide much needed empirical evidence about innovation success and failure at a time when greater understanding of innovation is vital to New Zealand's economy.

1.5 Research objectives

Regarding innovation we ask: what are the socio-technical parameters of the processes which lead to either the success or failure of technology users who innovate? How do innovations originate, develop, and diffuse from the actual inventor? In providing answers to these research questions, we can address an important policy question: how can innovation policy improve the likelihood of TUI success?

Accordingly, our main research objectives are to:

1. Identify the factors causally implicated in the commercial success or failure of technology users who innovate;

[5] NZ Statistics data is reproduced in Appendices 12 and 13: the smallest analytical unit is businesses employing 6-19 people.

2. Document how selective participation in the socio-technical networks surrounding invention affect innovation outcomes;
3. Extend our understanding of innovation within socio-technical networks by proposing a revised model of the TUI network;
4. Make policy recommendations relevant to the effective support of TUI in New Zealand.

1.6 Conclusion

This chapter has introduced the topic of technology users' innovation and given attention to current explanations of innovation success, arguing that a full understanding of this type of innovation requires considering the networks in which it occurs. In demonstrating fsQCA, we hope to expand the research tools available to Innovation Studies. By surveying each of three sectors and conducting interviews with key participants, as well as analyses of intellectual property (IP) and sectoral databases, we score selected TUI cases for their membership in selected socio-technical networks and identify configurations in their success or failure. The principal outcome of our approach is an increased understanding of the role of social networks in innovation, and the utility and competence of particular organisations in New Zealand's economic growth. Further, we describe the broad framework of innovation governance on TUI innovation processes. Chapter 2 describes our methods and Chapter 3 presents our data and analyses before these results are further discussed in two subsequent chapters.

Chapter 2
Methods

2.1 Introduction: QCA and innovation studies

While not wishing to disparage works that focus solely or primarily on success stories, the general reluctance of innovation research to deal with negative cases, that is, the failure of innovation, limits the insights that can be taken from such research. Further, in-depth studies often have only a small number of cases to draw on, and large-scale studies ignore the complexity evident within cases. While using semi-structured interviews across a range of case studies and key participants, we draw on Qualitative Comparative Analysis (QCA) to enable the systematic investigation across these. QCA approaches are particularly useful in studies of small to intermediate sample sizes while still incorporating the rich and insightful complexities of individual cases (Ragin, 1987; Rihoux & Ragin, 2009). These approaches pursue causal complexity through the use of set-theoretic methods and accept more than one configuration to an outcome. Essentially QCA approaches show fundamental relationships across multiple case studies where disparate data are available. Necessary and/or sufficient conditions can be identified, and results formatted through Boolean logic which enables the minimisation of configurations by identifying redundant variables.

We use a particular technique called fuzzy-set QCA (fsQCA) to identify system-wide configurations of participation in selected networks for both successful and unsuccessful examples of innovation, as well as fleshing out particular instances of this selective participation and the often very personal experiences of people which frame pertinent decisions. Variables are refined through successive analyses as results are referred back to cases to both utilise and challenge theory as empirical evidence comes from ever greater familiarity with case studies. Therefore at each stage of fsQCA we must be able to explain our decisions on the *degree* to which an innovation belongs to our selected networks and the criteria by which these decisions are made. The assumption is that individual inventors have considerable agency over their participation, and non-participation, in the key socio-technical networks of innovation.

QCA approaches have been used before in studies on innovation, typically focusing on the macro-level. Rihoux & Ragin (2009) examined organisational innovation by political parties. Fiss (2008) looked at the organisation of high technology firms, finding different causal configurations as one moves from average performance to high and very high levels of organizational performance. We take up this aspect of causal configuration when we come to discuss innovation success and its various expressions. Valliere, Ni, & Wise (2008) investigated 40 acquisitions of Canadian and US high-technology firms for the effects of ‘prior relationships’ between buyer and target firm on the purchase price, finding that specific combinations of prior relationship type are positively associated with higher prices. The authors note that one way to reduce information asymmetry is the exchange of private information prior to any proposal: ‘… commitment is enhanced by trust’ (p. 61).

At a smaller scale, Rizova (2007) examined six technology innovation projects for the ‘conjoint and simultaneous’ effects of selected innovation factors. In common with other researchers, Rizova identifies a significant problem as there are no universally accepted measures of success and failure. Of relevance to our research, she employed a typology reliant upon the degree the project met management expectations for 1. actual or potential financial returns; 2. satisfying the technical parameters of the project, and 3. staying within or exceeding the budget constraints.

In a New Zealand example, Birnie, Martin and Newman (2006) applied QCA to 25 entrepreneurs to investigate a model of 'alertness', confirming that successful innovation stemmed from recognising opportunities which they label 'economic events'. Spin-off opportunities were more commonly realised than radically new ventures, and the perception of uncertainty was a necessary condition of recognising an opportunity.

But none of these uses of QCA utilise the possibilities of fuzzy-set QCA which better models the real-world experiences of innovators where they variously participate in, for our purposes, socio-technical networks of innovation. These networks are a complex mix of markets, regulatory regimes, private firms, sectoral interests, and individual actions that affect innovation governance in New Zealand. Through familiarising ourselves with both the theoretical understanding of innovation (articulated by academic, industrial and government discourses) and the empirical data from our case studies, we identified several factors in innovation that are considered causal in any success. These results will be presented and discussed in a following chapter. Before this we consider identification of case studies, the process of scoring variables, the causal variables implicated in innovation success, and the outcome of success or failure. Some of the material presented in this chapter could itself be interpreted as results. However this reflects the nature of QCA approaches and their dialogue between theory and data (Ragin, 2000).

2.2 Identification and selection of case studies

The first step in QCA, as with most research, is the identification of appropriate case studies. While several researchers have undertaken extensive case study work on innovation in New Zealand (e.g., Gilbertson et al., 1995; Gilbertson et al., 1992; Winsley et al., 2001), these primarily focus on clearly successful innovations. As noted earlier, our focus is on what we have termed technology users' innovation (TUI) in the farming, building, and energy sectors. This focus stemmed from the need to complement existing New Zealand innovation research with attention to the less well-known TUI form of innovation. The three sectors chosen for study are important components of the economy and are likely to have both successful and unsuccessful cases. Our approach is both a valorisation and critique of the Kiwi back shed, 'number 8 wire' ingenuity, in seeking to better understand the operation of such innovation.

Finding TUI cases was relatively easy as there are many competitions to encourage and support inventors, and the media regularly presents cases of innovation. In the farming sector there are two national and many regional field days, each of which conducts competitions in a number of innovation categories. For the building sector, the Building Research Association of New Zealand (BRANZ) provided lists of all applicants for product registration which includes many building innovations as BRANZ accreditation is a standard criterion to satisfy councils. Yet in both sectors there are constraints to participation, with entry and exhibition fees for field days that range to several thousand dollars, and BRANZ operates on a cost recovery basis that several interviewees argued favoured large companies over small, disadvantaging the 'little guy'. Cases of TUI in the energy sector proved more difficult to identify. Partly this was due to the often very technical nature of energy innovation, certainly in comparison to the farming and building sectors. Many interviewees mentioned the confused policy and funding contexts of the energy sector, and noted how a wasteful culture of cheap energy had perhaps limited the innovation that was perceived as being needed.

It is not clear how representative these selected cases were in generating a sample of innovations by sector. While we have not canvassed all possible TUI cases, we are confident we have found sufficient cases to develop an understanding of causes of success or failure that will apply more generally to other cases. For all three sectors, we relied on word-of-mouth, media reports, internet searches and personal contacts at field days, seminars, and building sites. These strategies led to an incredible range of innovation, from individual solutions that were never intended to be commercialised to extensive projects involving highly skilled teams driven by the need for commercial success in exporting their technology. We will discuss how these innovations were scored for success in a following section. Appendix 11 lists all the case studies included in this research and provides a thumbnail sketch of each case; the interview schedule is given in Appendix 2. At this stage it is important merely to understand that a TUI case study is a case of invention by a technology user that may or may not be successfully commercialised as an innovation.

2.3 The process of scoring cases

FsQCA captures two aspects of diversity: differences of kind and differences of degree. Differences of kind exist where qualitative distinctions can be clearly drawn: cases belong to one of two distinct sets. For instance, it might be said of an innovation that it is protected by patent or it is not, i.e., a simple crisp set membership of 'in' or 'out'. However, for many social science studies can be characterised in terms of differences in degree. For example, innovations will generally have patent protection, and may be trademarked, protected by copyright, secrecy, or sheer complexity. The same considerations apply to the outcome of innovation; we do not dichotomise innovations as outright successes or failures, instead we can incorporate a range of outcomes based on the empirical expression of each case study of innovation and theories around the temporal, spatial and hierarchical characteristics of diffusion. This expression of intellectual property can be interpreted as a 'continuum of belonging', scored through careful attention to the data, including that from our extensive interviews, as well as theories, policies and practices that affect case studies.

Fuzzy membership scores are a measure of the degree to which case studies belong to categories, groups or 'sets' which are nominated by the researcher to be described and analysed. As we have argued, it is their selective participation of socio-technical networks that we seek to score cases. There are several steps in this process. First, researchers must specify the relevant domain of the assessment, beginning with the set of cases selected or available for investigation and the resonance these cases have with theory. In this research, we have identified cases of invention in the farming, building and energy sectors of New Zealand and analysed the social networks in which they sought to innovate.

Researchers must then designate the degrees of fuzziness relevant to the concepts being researched. The aim here is not to determine a case's position on a scale: fuzzy-set scores do not reflect a simple ranking of cases relative to each other. The degree of membership of, for instance, 'financially secure households' might be more insightful than the comparatively simplistic measure of 'household income'.

It is necessary to choose from one of several different types of fuzzy-set that is best for each concept. Ragin (2000) offers a number of frameworks for the transformation of crisp variables to fuzzy variables, reproduced in Table 2.1 below. While the crisp-set options are fully in or out, a simple three-value fuzzy-set logic allows cases to be located between full membership ('1') and full non-membership ('0') of a set by adding a third value ('0.5'). We utilise several types, including a crisp set, and work through these in greater detail for our selected variables.

Table 2.1: Crisp set variables compared to fuzzy-set variables

Crisp set	3-value fuzzy-set	5-value fuzzy-set	7-value fuzzy-set	‘continuous’ fuzzy-set
1 = fully in	1 = fully in	1 = fully in	1 = fully in	1 = fully in
		0.75 = more in than out	0.83 = mostly but not fully in 0.67 = more or less in	Numerical scores indicating that degree of membership is more in than out (0.5 < x < 1)
	0.5 = neither fully out nor fully in	0.5 = cross-over: neither in nor out	0.5 = cross-over: neither in nor out	0.5 = crossover: neither in nor out
0 = fully out		0.25 = more out than in	0.33 = more or less out 0.17 = mostly but not fully out	Numerical scores indicating that degree of membership is more out than in (0 < x < 0.5)
	0 = fully out	0 = fully out	0 = fully out	0 = fully out

Source: Ragin 2000: 156, Table 6.1.

Researchers must then determine the likely range of membership scores. This step emphasises an important distinction between fuzzy-set analysis and the conventional variable-oriented approaches. The conceptual midpoint of any fuzzy-set is 0.5, the ‘crossover point’. As a qualitative anchor, the midpoint is defined by the researcher with a rationale presented for each breakpoint.[6] These qualitative anchors enable relevant and irrelevant variations to be distinguished. For example, variation in GNP per capita among the world’s richest nations is not relevant to membership in the set of rich countries. While New Zealand is often said by disgruntled commentators to be on the verge of regressing to a Second or even Third World economy, a cursory examination of income at any level shows New Zealanders still well ensconced in the First World. However, such commentaries do point to this membership being less secure than previous periods in our history, a significant factor in the search for innovation at both the macro- and micro-scales.

Empirical evidence must be identified to allow the appropriate calibration of membership scores. For some studies, a conventional variable may be used, for example, using GNP per capita to decide upon a state’s membership of the set of ‘rich’ countries. It might be possible to utilise several conventional variables to index membership in a single set. However, in many studies, conventional variables may not be available or useful; the researcher may have to rely on qualitative evidence and in-depth knowledge of cases, and fit membership to three, five or seven-value, or continuous fuzzy-sets.

[6] In contrast, a conventional variable analysis is anchored by the ‘mean’, “an empirically derived measure of central tendency”, calibrated according to (sample specific) means and standard deviations (Ragin 2000:169). Ragin (2008) draws four distinctions between QCA approaches and standard statistical analyses in social science. First, QCA is a set-theoretic approach. Second, QCA is relies on calibrating data instead of blanket measurement. Third, QCA accepts configurations of conditions over the independence of variables. Fourth, the analyses executed under QCA are into causal complexity and not just net affects.

Finally, empirical evidence is translated into fuzzy scores. This involves linking raw scores – GDP, number of patents, manifestations of government support, or other kinds of evidence - to verbal labels. These scores are open to reassessment over the course of investigation acceptance of dialogue between ideas and evidence. While software has simplified both QCA and fsQCA, the steps outlined above show that putting fsQCA in practice involves considerable effort on the part of the researcher.[7]

Software is not an invitation to methodological monomania: in the warning of experienced practitioners, the approach works best in conjunction with other methods. Therefore we also draw heavily on interview data, gathered from over 60 interviews with people who often provided detailed experiences of working at a high level of expertise in specialist areas.

2.4 Causal variables: the key socio-technical networks in innovation

In the course of reviewing the literature, consulting with colleagues, case study participants, end-users, and through preliminary fieldwork, we identified many contributing variables. Ultimately we decided on five key networks as being causally significant in innovation[8]:

- Financial capital;
- Government support;
- Intellectual property regimes;
- Manufacturing;
- Business activities.

First, each of the five variables will be discussed in turn. In these discussions we will present insights and comments from our case studies. We will also discuss the outcome of innovation itself and show how fsQCA's ability to accept degrees of difference is particularly useful. Rather than categorise innovations as either successful or unsuccessful – the dichotomous approach of 'crisp set' QCA – we assign membership according to sales, profits, and the temporal, spatial and hierarchical characteristics of the diffusion of these innovations.

We were regularly challenged by what a case of TUI is actually a *case of.* Several initial case studies were ultimately excluded as our understanding of technology users' innovation became clearer and they fell outside the more refined definition. Recall that our focus is on technology users' as innovators, a term that is intended to encompass the phenomenon of 'Kiwi ingenuity' that, on the one hand, lies at the heart of a strong cultural identity held by New Zealanders, and on the other hand may be constraining in fully contributing to wider economic development. Many innovators were aligned with the market in a way that indicated their primary use of the technology was as a commodity for sale, and did not originate from, or encompass, the (almost banal) utility of the artefact and its use value. This classification issue posed problems in the energy sector, where an initial 20 case studies were whittled down to just ten as we refined and applied the criteria of technology users'

[7] Free software for QCA and fsQCA approaches is available from http://www.u.arizona.edu/~cragin/fsQCA/software.shtml. The Comparative methods for the Advancements of Systematic cross-case analysis and Small-n Studies (Compasss) website http://www.compasss.org/pages/welcome.html provides useful working papers and an extensive bibliographical database.

[8] The number of variables possible is in some respects limited by the number of case studies. In QCA, the total possible logical combinations is defined by 2^n, where n = the number of variables. Five variables give 32 logically possible combinations; six would give 64, an amount that would perhaps pose constraints on counterfactual analyses (that is, in finding cases that would potentially cover all the logically possible combinations of factors).

innovation, although this also suggests TUI is perhaps much less common in the energy sector. Those cases that were ultimately excluded from our study still contributed to our understanding of New Zealand’s innovation governance.

2.4.1 Financial capital

Financial capital is the most useful score on the cost of innovating, as well as the most common measure of its success. The ‘power’ of money to transform an idea into a prototype, an invention into an innovation, is not disputed; as one interviewee said ‘Really, the only thing you need to innovate is money!’ Smith (2006, p. 29) in his review of New Zealand ’s innovation policy framework noted: ‘Innovating is much more than learning or creating knowledge. It always involves a range of activities related to business that have little to do with technological capabilities’. Financial capital is perhaps the epitome of this statement and, significantly for our results, we found most case studies used their own income, savings and credit facilities. Venture capital and angel investors were used by some but were not common among our case studies; the small-scale and often possessive and self-directed nature of the TUI cases we examine are not characteristics that appeal to venture capitalists (Hellman & Puri, 2002) However, these characteristics do not mitigate the need for finance and in fact emphasise the role of social capital in securing financial capital for innovation.

As raw data, capital is recorded as a dollar value and is easily amenable to calibration as a continuous fuzzy-set. While software simplifies the operation of converting raw scores to fuzzy scores, the challenge for the researcher is to identify the three ‘qualitative anchors’ to the sets: full membership, full non-membership, and the cross-over point (0.5) where a case is neither in nor out of a nominated set. Table 2.2 below sets out the raw data for financial capital, their frequency, and shows where we have placed the three qualitative anchors of membership. fsQCA software works from these breakpoints to generate fuzzy scores which describe the **degree of membership** of each datum. Note that these fuzzy-set membership scores are not simply a ranking of cases relative to each other; scores are calibrated to indicate their degree of membership in a defined set, in this case the set of innovations funded by private financial capital.

Table 2.2: Fuzzy-set scoring for financial support (capital)

Capital ($)	frequency	Fuzzy score
0	3	0.02
500	1	0.03
1,000	2	0.03
2,000	1	0.03
5,000	1	0.04
7,500	Fully ‘out’	
10,000	3	0.06
20,000	1	0.14
25,000	2	0.20
40,000	Cross-over	
50,000	1	0.52
70,000	1	0.55
80,000	1	0.56
100,000	8	0.60
150,000	1	0.67
200,000	5	0.74
250,000	2	0.8
350,000	1	0.88
500,000	Fully ‘in’	
600,000	1	0.97
650,000	1	0.98
1,000,000	5	1
1,500,000	1	1
1,600,000	1	1

2.4.2 Government support

The drive for innovation is a fundamental feature of contemporary political economics and some forms of state support for innovation appears universal. As shown earlier in Table 1.1, New Zealand does not invest a commensurable proportion of GDP to R&D as its OECD ‘neighbours’ but this in itself, while being a characteristic of New Zealand innovation governance, cannot explain the level of innovation in New Zealand. There are in fact a wide range of government funding and other support programmes for innovation. Government financial support for our case studies originates from one or more of the programmes collated in Williams (2008; see Appendix 1) with cases securing from $5,000 to several hundred thousand dollars. Support is also offered through government organisations such as business mentors and innovation ‘incubators’, as well as accessing university students, government employees and/or research facilities, sometimes on an informal basis. Where present, this form of support has been incorporated into the scoring of case study support by government for each case study.

A majority of our cases (26 in total of 43) received no support by government, either through ignorance of what support was available or a deliberate decision not to seek support. Others abandoned efforts to apply for government support due to the complexities and costs in time of the applications process. As one person said:

You have to have a degree just to figure out how to fill out the form!

There were disparate types of support recorded: financial, pastoral, professional advice and/or training, or facilitation. Because of the often crucial role of this support, regardless of its extent or size, we decided on a crisp-set scoring to interpret government support.

Table 2.3: Crisp-set scoring for Government support (Govt)

No govt. support	Any type of govt. support
0	1

2.4.3 Intellectual property

Legal rights to IP feature in most government and corporate conceptions of innovation governance[9]. What struck us from the outset of fieldwork was the disdain which some of our informants held for IP in general and patents and lawyers in particular. This attitude was not necessarily one of ignorance as several of these interviewees owned previous, often very lucrative, IP and most innovators will own copyright to relevant aspects of their work.

Yet as many people noted, possession of a patent does not preclude the use or commercialisation of an innovation by others, albeit illegally. Thus while IP is dependent on a macro-social recognition of exclusion, it is determined at the micro-level by the decision to pursue or ignore enforcing these rights and is contingent upon costs, including time and effort.

These insights disqualify the scoring of IP as a crisp variable: zero for no IP and 1 for IP 'protection'. As our data accumulated, a more nuanced approach was seen as better describing the IP context of case studies. Using interviews, the internet and the various IP databases, particularly the Intellectual Property Office of New Zealand (IPONZ) it was possible to collate the IP associated with an innovation (i.e., through its inventor, his/her company, other businesses, their families and life experiences). We then assigned a score of '2' to each relevant patent, trademark, copyright or design; and a score of '1' to each of voided or expired IP (evident in several cases) to reflect both the formal and tacit knowledge the experience lent to inventors.

We decided that a case study with a total score of more than 7, however that score was made up, was a full member of the socio-technical network associated with the IP regime. Any case scoring less than '1' was fully out of this network, and the score of 3 was a point of maximum ambiguity, where a case would neither in nor out of this set. This value was chosen to reflect the experiences of case studies where copyright or mere ownership of a patent did not necessarily provide complete protection. What this fuzzy-set scoring allows us to do is weight

[9] New Zealand's intellectual property regime is governed through the 1953 Patent Act, based on British legislation dating from 1939. It is currently under review.

membership towards those innovations that have a more extensive participation within the networks of IP.

Table 2.4: Fuzzy-set scoring for IP

Raw IP score	frequenc y	Fuzzy score
0	1	0.02
0.5	Fully 'out'	
2	13	0.26
3	Cross-over	
4	9	0.66
5	2	0.79
6	6	0.88
7	2	0.94
7.5	Fully 'in'	
8	3	0.97
9	1	0.99
10	1	1
11	1	1
12	1	1
13	1	1
16	1	1
31	1	1

2.4.4 Manufacturing

The image of the single-minded, even eccentric, inventor toiling in a cluttered workshop resonates with many people in New Zealand, especially in the rural or farming sector. Most case studies built their own prototypes and many built the final technological artefact. Several innovators showed us their first prototype, in one case a series of attempts in different materials to solve a particular problem. Another case study built – and then gifted to us – a working scale-model to test a solution for a particular problem raised during an interview. Most TUI innovators were spoken of as 'very clever', 'very practical', and 'good with their hands', all standard expressions from 'Kiwi ingenuity' mythos but here manifested in technological artefacts that are variously ascribed as novel, innovative, and potentially commercial.

The inventor often retained a role in manufacturing, generally through their own firm, but would also contracted out other aspects due to realities of expertise, scale or productivity. Where other firms were involved these were often small local engineering firms, although quite geographically extended networks were also evident. Some innovations such as software applications or wind turbines are so complex that collaboration or partnership with other firms was vital, and often large teams were assembled to undertake production.

We have chosen a 6-value fuzzy-set to score the amount of manufacturing an innovator undertakes or controls. Eight of our cases undertook no manufacturing of their innovation at all, a further nine undertook minor or some manufacturing; 26 cases were considerably, mostly or entirely manufactured by the innovator.

Table 2.5: 6-value scoring for the amount of manufacturing an innovator undertakes (Manu)

	Freq.	**Fuzzy Score**
None	8	0
Minor	5	0.17
Some	4	0.33
Considerable	6	0.67
Most	12	0.83
All	8	1.0

2.4.5 Business activities

What was often mentioned by our interviewees was the utility of other business networks in which the inventor and his or her supporters participated, a finding that mirrors that of other *innovation researchers. This insight into innovators' business activities led us to incorporate* these activities into a crisp variable whereby if an inventor engaged in businesses outside of their immediate technological sphere, then they were judged as having 'other business activities'.

Table 2.6: Crisp-set scoring for business activity (Biz)

Inventor has just one business activity	Inventor has more than one business activity
0	1

An important extension of this is seen with husband and wife 'teams' in which one spouse (usually the wife of the inventor) has employment in another sector that carries with it other skills and contacts. Such cases would be scored '1'. Overall, 29 of our case studies were engaged in more than one business activity, comprising around two thirds of all cases.

2.5 The outcome: innovation success or failure (S)

What marks an innovation as a success will be seen as remarkably fuzzy, and not at all the crisp (i.e., dichotomous) score of 'yes, successful', or 'no, not successful'. Standard macro political-economic indicators of success are presented as simple to score yet are clearly extremely difficult to influence. Increased GDP, higher rate of economic growth, more publications, patents or PhD graduates are typically taken to reflect innovation. Yet in our case studies inventors themselves reflected a nuanced interpretation of their own success or failure. All noted their inventions 'worked' by solving the particular problem that prompted the attempt in the first place. Yet when confronted with the difficulties of production and commercialising their invention, many conceded they were not very, or not yet, successful.

Rizova (2007) observes no universally accepted measures of success at the project level through interviewing laboratory directors who were asked to classify projects as successful or not based on the degree to which each project met management's expectations in terms of actual or potential financial returns, satisfying the technical parameters, and staying within or exceeding the budget constraints. From this data she ascribed scores of 'high' or 'low' success. We have accumulated considerable data through a range of case studies, including people associated throughout the networks of support, yet still acknowledge a difficulty in categorising such a wide range of innovations into successes or failures.

Our understanding of innovation success has been aided by a number of analytical perspectives. To better understand the outcome of innovation, we drew on insights into the temporal, spatial, institutional and social characteristics of diffusion that originated with innovation diffusion studies dating back to the 1920s.[10] For our study we have ascribed success according to the degrees of spatial, temporal and hierarchical diffusion achieved by a case study. Any innovation that was successfully exported was given full membership. This is in part justified on the grounds that New Zealand government innovation policy is primarily directed to achieving export success but also from the evidence of case studies actively seeking export success as a goal. Extensive national sales and distribution was scored 0.8; regional and/or limited national sales 0.6. Innovations that had some limited success but are no longer sold or manufactured were scored 0.4; those that only achieved local sales and diffusion, or very limited national sales, were scored 0.2. Innovations with no sales were clearly non-members of the set of successful innovations and scored 0. This scoring system is outlined in Table 2.7. Note that not all inventors were motivated to succeed commercially and their, admittedly minor, role in our study nevertheless is very useful in understanding innovation by technology users. We think this particular method of discerning between types of innovation success is a very useful methodological advance in innovation studies.

Table 2.7: 7-value scoring for innovation outcome (Success)

	Freq.	Fuzzy Score
Failure	3	0
Partial Success	9	0.2
Some Success	1	0.4
Neither success nor a failure	3	0.5
Limited national sales	8	0.6
Successful domestically	14	0.8
Successful exports	5	1.0

[10] The diffusion of innovations has occupied a central position in a number of disciplines at various stages of their development, notably rural sociology, geography and medical sociology in the 1950s and 60s, and marketing in the 1980s and 90s (see Rogers, 2005; Rogers & Scott, 1997; Rogers & Shoemaker, 1971).

An interesting extension of the debate about innovation success is the role that technological failure or irrelevance has on innovation failure. It may be that a particular innovation fails because it is inherently useless, perhaps the result of an obsession of the inventor.[11] At an early stage of the research, scoring the number of awards won by an innovation was considered as a variable to counter this challenge although it was soon discovered there were a plethora of awards and, like IP, an award was no guarantee of success. We accept this methodological challenge has not been resolved in our current research although we do argue that the fuzzy-set approach mitigates this issue while still addressing key policy concerns.

2.6 Additional data sources

While the focus of fsQCA is necessarily on cases studies, in order to understand how people in the case study reacted to people in their social network it is generally necessary to include other data. To this end, we draw on both qualitative and quantitative data for our analyses from various databases, media reports, government and industry reports, and statistics. Importantly we conducted a series of semi-structured interviews with New Zealand inventors as well as other participants in the innovation networks including IP lawyers, incubator personnel, and government officials within MED, MoRST, BRANZ, and EECA. The insights gained from these interviews provide the substantive knowledge on which we can score cases for our fsQCA.

2.7 Conclusion

This report contributes a new approach to describing and analysing innovation by analysing cases of invention in New Zealand according to their membership of key socio-technical networks. In describing cases and outcomes, we combine qualitative and quantitative data and accept causation will be multi-factorial and that more than one pathway to success will probably exist.

To summarise, we have investigated selected innovations by technology users in New Zealand’s farming, building and energy sectors to describe and analyse the various configurations of memberships in the key socio-technical networks surrounding the invention: financial capital, government support, IP, manufacturing and other businesses. In scoring and interpreting these memberships we also drew on other data gathered through interviews, database searches, interviews with other participants in these specialised networks, and media sources. Data were often disparate, and included innovators’ life stories, formal education and training, informal training, attempts at advertising and marketing (including market research), and their experiences negotiating often complex regulations and regulatory organisations.

Fuzzy-set Qualitative Comparative Analysis of the data based on membership of TUI cases in the five variables – financial capital, government support, IP, manufacturing, business activities – and the outcome (innovation success) will enable the identification of particular combinations of memberships associated with innovation success and failure. The analysis was extended by using interview data, media reports, and various databases to gain further insight into the relevant socio-technical networks and their innovation governance.

[11] At a workshop on Intellectual Property, IP lawyers said that were approached ‘at least once a year’ from someone who argued they had invented a perpetual motion machine, and in one interview it was revealed the inventor was working on just such a machine.

Chapter 3
Case Study Results

3.1 Background characteristics of the inventors

Before giving the technical results of fsQCA, we believe it is helpful to present some of the comments of our interviewees. The majority of interview subjects were the inventors themselves, most of whom were male aged between 35 and 65. Most interviews were conducted face-to-face although several were undertaken by telephone. Interviews were semi-structured with a list of basic questions (See Appendix 2); more detailed data for each case are provided in Appendix 11. Most of these innovators were known as highly-skilled practical people, as well as being independent, often fiercely so.

I've never accepted the status quo…that's been the case since I was a child.

A few friends have given me the confidence to carry on but basically me. I'm the one that comes up with all the ideas. Like I ask other people how they think, they just haven't got a clue, I'm basically the one that puts the whole thing together.

I guess I've always been going in a different direction from the crowd.

I think I am an outsider, I don't have a great band of friends, the friends that I do have are just largely great acquaintances. I have a couple of very close mates but I don't socialise at all to be honest with you. I am very happy doing my own thing as an individual. That's always been me.

My family think I am obsessed. I probably am.

Most inventors were very self-effacing:

'We' as in 'me'. I don't like saying 'I', I'm not a very good on my I's, not at all.

Money was often downplayed. One interviewee said "I don't want to be rich but I would still like to be comfortable when I retire because I've put in a lot of effort". Another said the money was the 'score', the way you judged success. Another noted how her father, the inventor, was "pretty Scottish with his money you know, the moths come out when he opens his wallet". Family inheritance – of skills, knowledge and capital, was regular factor in these innovators (almost always a father-son relationship). The pride was obvious if often understated:

Both my sons have got the same skills and the same involvement in life and they will make anything and make it work.

Several interviewees expressed a sense of isolation:

> *This might sound terribly selfish, there is no help whatsoever and it's a really lonely place because there is nobody that is doing what we are doing and it took us years of going to the field days to actually meet a few other people and now we try and support each other a bit. We have got no organization, no union, no anything and when I go to town or whatever and meet up with people they have got no idea ….*

One person in the building sector gave this interesting response to the question of whether he was an inventor or a business person:

> *I hate the term inventor, with a passion…it makes you sound like some goof you know. If anybody asks me I just tell them something. The words saying I have invented something has never passed my lips, I just designed this product.*

Several interviews ended with interesting tangents about young people, their schooling, and the skills and attitudes of young workers.

> *To build something new, anyway, you have to have a need for it, or see an opportunity or a possibility, and actually create something from nothing. And my impression…is that more of the younger ones coming on don't do that, don't think along those lines, don't do that well in real-world things.*

Success was viewed very differently by many inventors. For one, just having a single product on the shelf was success:

> *And I've done it! Everything else is icing on the cake.*

> *Never had it and I don't know … It was wonderful when I was accepted by my wife first of all… that was a feeling of success. It was another feeling of success when I got through my combined chefs examination in Glasgow, just a few weeks before we were married, that was elation. And when my patent was first accepted internationally in Geneva.*

The emphasis on the technical aspects of TUI participants often highlighted their lack of skills in other, subsequent, aspects of innovation such as marketing.

> *He was so enthusiastic but he didn't want to do any of the selling or anything but he liked working it all out.*

Many in the building and energy sectors nominated sustainability goals and ethics as being very important to their innovation attitude. For some it had framed their current working lives and strategies for work in the future, but they remained grounded in economic viability.

The point is for me it's always an economic proposition. We can't tax and fund ourselves into a sustainable future so if we are going to actually deliver the sustainable future it should pay, and everybody says environmentalism pays in the long term but the point is it pays in the short term.

We shall return to interview data in Chapter 5. At this point we draw attention to the practical, self-directed nature of TUIs. These are characteristics we might expect, given their elevation as quintessential Kiwi male traits - most of our TUIs are men in their 40s, 50s and 60s. However, recall the discussion of variables in the previous chapter. We know that nine of our case have invested over half a million dollars, and that despite their professed independence, many have accessed government help in one form or another. Many also possess some form of intellectual property around their innovations and have involved others in manufacturing their product as well as being involved in other businesses. These networks will be revisited in the concluding chapter. The rest of this chapter presents the fsQCA results.

3.2 fsQCA data

The scores listed below in Table 3.1 enable the fundamental set relationships to be described, a key step in fsQCA is identifying necessary and/or sufficient causal conditions. When causation is complex - and that is the situation for most social change and certainly the situation for any form of innovation - no single cause may be found to be either necessary or sufficient. Causes will generally only be found to be sufficient, and even then only in combination with other causes. For each membership in the constructed sets, for example 'CAPITAL', there is a corollary non-membership (~X = 1 - X), represented with lower-case, e.g., 'capital'.

This table should be read in conjunction with Table 3.2 which displays the truth table that is derived from these data. Successful case are coloured green, unsuccessful cases are coloured red, and yellow is used for cases where it is not possible to decide if the cases are successful or unsuccessful. Orange denotes a configuration which contains both successful and unsuccessful cases.

Table 3.1: TUI data table of variable scores for all cases

Case	CAPITAL	capital	IP	ip	MANU	manu	BIZ	biz	GOVT	govt	S
FARMING											
F1	0.6	0.4	1	0	0.83	0.17	1	0	1	0	0.8
F2	0.02	0.98	0.23	0.77	1	0	0	1	0	1	0
F3	0.04	0.96	0.66	0.34	0.67	0.33	0	1	1	0	0.6
F4	0.6	0.4	1	0	0.83	0.17	1	0	0	1	1
F5	0.03	0.97	0.23	0.77	1	0	0	1	0	1	0.2
F6	0.06	0.94	0.66	0.34	0.17	0.83	1	0	0	1	0.8
F7	0.6	0.4	0.97	0.03	0.83	0.17	1	0	0	1	1
F8	0.03	0.97	0.23	0.77	0.33	0.67	1	0	0	1	0.8
F9	0.03	0.97	0.23	0.77	0.33	0.67	0	1	0	1	0.2
F10	0.52	0.48	0.94	0.06	0.17	0.83	1	0	1	0	0.6
F11	0.88	0.12	0.23	0.77	0.83	0.17	1	0	0	1	0.2
F12	1	0	0.66	0.34	1	0	1	0	1	0	0.8
F13	0.02	0.98	0.03	0.97	0.67	0.33	0	1	0	1	0
F14	0.03	0.97	0.23	0.77	1	0	0	1	0	1	0.2
F15	0.6	0.4	0.66	0.34	0.83	0.17	1	0	1	0	0.8
F16	0.14	0.86	0.23	0.77	0.83	0.17	1	0	1	0	0.2
BUILDING											
B1	0.6	0.4	0.97	0.03	0.67	0.33	1	0	0	1	0.8
B2	0.8	0.2	0.79	0.21	0.17	0.83	0	1	1	0	0.8
B3	1	0	0.94	0.06	0	1	1	0	0	1	0.5
B4	0.67	0.33	0.66	0.34	0.83	0.17	1	0	1	0	0.6
B5	1	0	1	0	0	1	1	0	1	0	1
B6	0.06	0.94	0.23	0.77	1	0	0	1	1	0	0.6
B7	0.56	0.44	0.03	0.97	0.83	0.17	1	0	0	1	0.2
B8	0.6	0.4	0.88	0.12	0	1	1	0	0	1	0.4
B9	1	0	0.88	0.12	0.83	0.17	1	0	0	1	0.8
B10	0.74	0.26	0.88	0.12	0	1	0	1	0	1	0.6
B11	0.8	0.2	0.88	0.12	0.33	0.67	0	1	0	1	0.6
B12	0.97	0.03	0.66	0.34	1	0	1	0	0	1	0.8
B13	0.74	0.26	0.99	0.01	0	1	1	0	1	0	0.8
B14	0.06	0.94	0.23	0.77	0.33	0.67	0	1	0	1	0.2
B15	0.74	0.26	1	0	0	1	1	0	0	1	0.8
B16	1	0	0.97	0.03	0.67	0.33	1	0	1	0	0.8
B17	1	0	0.66	0.34	0.83	0.17	1	0	1	0	0.5
ENERGY											
E1	0.55	0.45	0.66	0.34	0.17	0.83	1	0	1	0	1
E2	0.74	0.26	0.98	0.02	0	1	0	1	0	1	0.8
E3	1	0	1	0	1	0	1	0	1	0	0.6
E4	0.2	0.8	0.66	0.34	1	0	0	1	0	1	0.2
E5	0.6	0.4	0.88	0.12	0.17	0.83	1	0	0	1	0.6
E6	0.2	0.8	0.03	0.97	0.67	0.33	1	0	1	0	0.2
E7	0.98	0.02	0.66	0.34	0.83	0.17	1	0	1	0	0.8
E8	0.02	0.98	0.23	0.77	0.67	0.33	0	1	0	1	0
E9	0.6	0.4	0.88	0.12	0	1	1	0	1	0	1
E10	0.74	0.26	0.79	0.21	0.83	0.17	1	0	1	0	0.5

3.3 Overall fsQCA analysis results

Table 3.2: TUI truth table

	k*ip*m*b*g	k*ip*m*B*g	k*ip*M*b*g	k*ip*M*B*g	k*IP*m*b*g	k*IP*m*B*g	k*IP*M*b*g	k*IP*M*B*g	K*ip*m*b*g	K*ip*m*B*g	K*ip*M*b*g	K*ip*M*B*g	K*IP*m*b*g	K*IP*m*B*g	K*IP*M*b*g	K*IP*M*B*g	k*ip*m*b*G	k*ip*m*B*G	k*ip*M*b*G	k*ip*M*B*G	k*IP*m*b*G	k*IP*m*B*G	k*IP*M*b*G	k*IP*M*B*G	K*ip*m*b*G	K*ip*m*B*G	K*ip*M*b*G	K*ip*M*B*G	K*IP*m*b*G	K*IP*m*B*G	K*IP*M*b*G	K*IP*M*B*G	
N	2	1	5			1	1					2	3	4		5			1	2			1	0				0	1	5		9	
n			1				1						1	1						1				0						2		3	
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.17 0		0.21 0		0.17 0		0.26 0		0.17 0		0.21 0		0.17 0		0.79 0.5
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.12 0	0	0		0.4 0	0	0		0.12 0	0	0		0.6 0	0	1
		0.33 0		0.67 0		0.23 0		0.23 0		0.02 0		0.02 0		0.02 0		0.02 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.02 0		0.02 0		0.02 0		0.02 0		0.17 0		0.34 0		0.17 0		0.66 0.8
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.33 0		0.67 0		0.03 0		0.03 0		0.2 0		0.2 0		0.03 0		0.03 0.2
	0		0.12 0		0.12 0		0.4 0		0.17 0		0.12 0		0.12 0		0.6 0		0.17 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
	0	0		0.34 0	0	0		0.66 0	0	0		0.2 0	0	0		0.2 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.6
		0.02 0	0	0		0.26 0	0	0		0.02 0	0	0		0.74 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.34 0		0.17 0		0.45 0		0.17 0		0.34 0		0.17 0		0.55 0		0.17 1
n	1											1	2	3		3			1				0						1	2		3	
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.17 0		0.34 0		0.17 0		0.66 0.5
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.03 0		0.03 0		0.33 0		0.67 0.8
	0	0	0	0	0		0.26 0	0	0	0	0	0	0		0.74 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
		0.67 0		0.33 0		0.23 0		0.23 0		0.06 0		0.06 0		0.06 0		0.06 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.01 0	0	0		0.26 0	0	0		0.01 0	0	0		0.74 0	0	0.8
	0	0	0		0.03 0	0	0		0.03 0	0	0		0.34 0	0	0		0.66 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
		0.12 0		0.12 0		0.2 0		0.2 0		0.12 0		0.12 0		0.67 0		0.33 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
		0.12 0	0	0		0.26 0	0	0		0.12 0	0	0		0.74 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
	0	0	0	0	0	0	0	0	0		0.12 0		0.12 0		0.17 0		0.83 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
	0		0.12 0	0	0		0.4 0	0	0		0.12 0	0	0		0.6 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4
	0		0.17 0		0.44 0		0.03 0		0.03 0		0.17 0		0.56 0		0.03 0		0.03 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.77 0	0	0		0.23 0	0	0		0.06 0	0	0		0.06 0	0.6
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.17 0		0.33 0		0.17 0		0.33 0		0.17 0		0.34 0		0.17 0		0.66 0.6
	0	0	0	0	0	0	0	0	0		0.06 0	0	0		0.94 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.2 0		0.17 0		0.2 0		0.17 0		0.21 0		0.17 0		0.79 0		0.17 0	0.8
	0		0.03 0		0.03 0		0.33 0		0.4 0		0.03 0		0.03 0		0.33 0		0.6 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
n	1	1	4			1						1				2				1			1							1		3	
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.17 0		0.77 0		0.17 0		0.23 0		0.14 0		0.14 0		0.14 0		0.14 0.2
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.17 0		0.34 0		0.17 0		0.4 0		0.17 0		0.34 0		0.17 0		0.6 0.8
	0	0		0.77 0	0	0		0.23 0	0	0		0.03 0	0	0		0.03 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
		0.33 0		0.67 0		0.03 0		0.03 0		0.02 0		0.02 0		0.02 0		0.02 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.34 0	0	0		0.66 0.8
	0		0.12 0		0.12 0		0.12 0		0.12 0		0.17 0		0.77 0		0.17 0		0.23 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.06 0		0.06 0		0.48 0		0.17 0		0.06 0		0.06 0		0.52 0		0.17 0.6
		0.67 0		0.33 0		0.23 0		0.23 0		0.03 0		0.03 0		0.03 0		0.03 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	0		0.67 0		0.33 0		0.23 0		0.23 0		0.03 0		0.03 0		0.03 0		0.03 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
	0		0.03 0		0.03 0		0.17 0		0.4 0		0.03 0		0.03 0		0.17 0		0.6 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0		0.34 0		0.17 0		0.66 0		0.17 0		0.06 0		0.06 0		0.06 0		0.06 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
	0	0		0.77 0	0	0		0.23 0	0	0		0.03 0	0	0		0.03 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
	0	0	0	0	0		0.17 0		0.4 0	0	0	0	0		0.17 0		0.6 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.33 0		0.34 0		0.33 0		0.66 0		0.04 0		0.04 0		0.04 0		0.04 0	0.6
	0	0		0.77 0	0	0		0.23 0	0	0		0.02 0	0	0		0.02 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.17 0		0.4 0	0	0	0	0		0.17 0		0.6 0.8
S																																	

From the data table (Table 3.1) we construct a 'truth table' in which each case's membership in all possible logical combinations of variables is displayed (Table 3.2). With the five variables we have chosen, 32 logical combinations exists. What follows is a number of iterations of the causal configurations associated with technology users' innovation. The overall results for both success and failure are presented first. Details of the full fsQCA workings are given in the Appendices. As a reminder to how to read these results, note the following definitions:

CAPITAL	well financed
capital	poorly financed
GOVT	supported by government
govt	not supported by government
IP	protected IP
ip	unprotected IP
MANU	inventor undertakes considerable, most, or all of the manufacturing
manu	inventor undertakes none, minor, or some of the manufacturing
BIZ	the inventor engages in other business activities
biz	the inventor does not engage in other business activities.

3.3.1 Pathways to success

The overall truth table in Table 3.2 clearly shows the successful and unsuccessful cases (coloured green and red respectively). In all there were 27 cases of success and three cases scored at 0.5 (allocated to cases that it was not yet possible to decide on their success or failure; coloured yellow). Of the successful cases, 22 were represented by just four configurations, and a further five configurations of success with single examples. We found 12 cases of failure across five configurations, and one configuration represented by a single example giving 13 cases of failure in total. One configuration (shown in orange) had two successful, one failed, and one 'cross-over' case (not fully in nor fully out and is scored at 0.5).

There are two steps in the analysis. First we start with configurations present in the truth table. Then we introduce results derived through the fsQCA software. We initially focus on successful configurations for which there were multiple cases and omit those with single examples and the one 'pathway' that showed both success and failure. The most common configuration of success was:

CAPITAL*GOVT*BIZ*MANU*IP (n=9)

In plain language, a successful innovation was well supported financially, supported in some way by government, with the inventor engaged in other business activities and undertaking considerable manufacturing of the innovation, while also holding relevant IP protection. In effect, these inventors achieved innovation success because they were effectively participating in all the key networks surrounding them and their invention.

This result might seem obvious, merely confirming what seems common sense and what other studies have explicitly or implicitly found. However, two other significant configurations were:

CAPITAL*GOVT*BIZ*manu*IP (n=5) and
CAPITAL*govt*BIZ*MANU*IP (n=5)

These configurations differ from the first by, in the second configuration, the absence of manufacturing (i.e., the inventor undertakes none, minor or some of the manufacturing) and in the third by the absence of government support.

But these results do not make use of QCA Boolean logic which allows terms to be minimised by excluding so-called redundant factors. So for the two solutions above, we can see that the term CAPITAL*BIZ*IP covers the common factors of both configurations while being logically simpler.

One other configuration is also worth noting:

CAPITAL*govt*biz*manu*IP (n=3)

In plain language again, three successful innovations were characterised by being well financed but not supported by government, with the inventor not engaged in other business activities and not undertaking significant manufacturing of the innovation, though still having relevant IP.

Turning now to the software results we consider the minimisation processes alluded to above, which enables three types of solutions to be derived - complex, parsimonious, and intermediate - based on different treatments of 'remainders', those combinations for which there is no empirical evidence. For complex solutions, all remainders are treated as 'false', i.e., do not demonstrate the outcome. The parsimonious approach sees the utilisation of any remainder that will help generate a logically simpler solution, regardless of whether it constitutes an 'easy' or a 'difficult' counterfactual case. The intermediate approach incorporates only those remainders that are 'easy' counterfactual cases into the solution. The designation of 'easy' versus 'difficult' is based on insights the researcher has on substantive and theoretical connections between causal conditions and outcomes. Our assumptions – arrived at through our interviews and the empirical evidence of our final 43 case studies as well as a further 12 cases not included – are that financial support, government support, and business connections should contribute to successful innovation. 'Easy' counterfactuals assume that adding a superfluous variable to a configuration known to result in the outcome would still produce the outcome. 'Difficult' counterfactuals attempt to remove a variable from a configuration that displays the outcome on the assumption that this variable is redundant and the simplified configuration would still produce the outcome (see Ragin & Sonnett, 2004).

Therefore we present software minimisation results, thus drawing attention to the key configurations common to success and failure. In what follows, **raw coverage** refers to the proportion of the outcome explained by each term of the solution. **Unique coverage** measures the proportion of the outcome explained *solely* by each individual solution. **Consistency** is a measure of the degree to each solution term is a subset of the outcome. **Solution coverage** measures the proportion of the outcome explained by the complete solution. **Solution consistency** measures the degree to which the solution terms are consistent with being a subset of the outcome.

All these technical terms can be seen and better appreciated with our first presentation of fsQCA results. Analysing successful TUI cases across all three sectors, excluding single examples, and derived through the intermediate approach, show two key configurations:[12]

	raw coverage	unique coverage	consistency
CAPITAL*manu*IP	0.451822	0.115790	0.926141
CAPITAL*BIZ*IP	0.604049	0.268016	0.893413

solution coverage: 0.719838
solution consistency: 0.897527

In plain language these results show that technology users who are:

- Well financed, not undertaking significant manufacturing, and holding relevant IP; or,
- Well financed, engaged in other businesses, and again with relevant IP.

...are more likely to succeed. In the terminology of fsQCA, the first solution 'covers' or explains 45 per cent of the outcomes, about 12 per cent of which are *only* covered by this term, which is 93 per cent consistent with the outcome. The second solution covers 60 per cent of the outcome, 27 per cent of which is only covered by this term, and it is nearly 90 per cent consistent with the outcome. Together the two 'solutions' cover 72 per cent of the outcome and are about 90 per cent consistent with that outcome.

However, as Table 3.2 shows, we actually have considerable complexity in the results. The five successful configurations with single examples are not given emphasis in these results in order to focus on the configurations with firmer empirical evidence, rather than on those that might be somewhat idiosyncratic (see Appendix 3). These individual configurations are, however, incorporated in the results given in full in the appendices. Note that two of these configurations (cases F8 and B6) show the *lack* of IP, which, given the varied and interesting experiences discussed by our TUI cases in their dealings with IP networks, mean we do not ascribe causal power to IP in and of itself.

Overall, these results remind us that an inventor may still achieve success by configurations other than the ones we have emphasised. We will bring the complexity back into our results in a following section and at this point simply draw attention to the strongest configurations of success.

3.3.2 Pathways to failure

The main configuration of failure was:

capital*govt*biz*MANU*ip (n=5)

Failed innovations were generally unsupported by financial capital or government, with the inventor not engaged in other business activities and lacking relevant IP protection but undertaking most of the manufacturing. It should be noted that this configuration describes the archetypal Kiwi 'back shed' inventor: good at making, and then 'tinkering' with an

[12] Several operational details are also given through the software application, namely in this example a frequency cutoff of 2 and a consistency cutoff of 0.872781; and the 'assumptions' for treating remainders, in this case that the presence of CAPITAL, GOVT and BIZ contribute to the outcome.

invention, but giving disproportionate attention to this part of the process at the expense of other necessary aspects.

We also present the software results for failure, again excluding single examples:

	raw coverage	unique coverage	consistency
capital* govt*biz*ip	0.338251	0.338251	1.000000
CAPITAL*govt*BIZ*MANU*ip	0.103279	0.103279	0.917476
capital*GOVT*BIZ*MANU*ip	0.123497	0.123497	0.879377

solution coverage: 0.565027
solution consistency: 0.955638

Again, using the terminology of fsQCA, the first configuration covers 34 per cent of the outcome and is 100 per cent consistent with that outcome. However, note the low coverage of this solution. The remaining two terms have less explanatory power (and are less consistent), confirming what we have found through our interviews. These are important results as they show that failure is not solely a case of the inventor shutting themselves in their workshop. Recall that we define success of an innovation according to the characteristics of its diffusion. It was not possible to judge an innovation on its technical 'competency', that is, how good a widget or process was compared to competitors. These results highlight the lack of participation in those socio-technical networks previously identified as important to innovation success. However, we also see that innovators who are participating in some of the key networks, such as financial capital, government support, and other businesses, can still fail. Appendix 4 presents more detailed data on overall failure.

3.3.3 Comparisons across sectors

In this short section we compare between each of our three sectors. These sectoral results show some variation in the configurations of success or failure across sectors (Tables 3.3 and 3.4 respectively). While at first glance these tables may seem to indicate very different configurations, we advise checking these results against the truth table (Table 3.2) which shows the distribution of cases across relevant configurations. We draw attention to the strong presence of financial capital for success, the regular appearance of business networks (especially in farming), and the coupling of government support with innovator-led manufacturing.

Table 3.3: Comparison between sectors for innovation success

Term	Farming	Building	Energy
CAPITAL*BIZ*IP	X	X	
GOVT*MANU*IP	X		
BIZ*manu	X		
GOVT*MANU*ip		X	
CAPITAL*manu*IP		X	X
CAPITAL*GOVT*BIZ*IP			X

We found less variation in the pathways to failure, again something which can be verified from Table 3.2. The absence of financial support in failure is expected in these cases, as is the inventor undertaking considerable manufacturing. As with the overall results for failure, we see inventors/innovators not participating significantly in the socio-technical networks found to be relevant for innovation in New Zealand. Appendices 5 to 10 include the detailed results for success and failure in each of the sectors.

Table 3.4: Comparison between sectors for innovation failure

Term	Farming	Building	Energy
capital*MANU*ip*	X		X
govt*MANU*ip*	X	X	
capital*govt*biz*ip	X	X	
capital*govt*MANU*biz			X

3.4 Conclusion

This chapter has presented the results of a fuzzy-set Qualitative Comparative Analysis of technology users' innovation and found a number of different configurations to their success and failure. The most powerful configurations of success was to be well financed, not undertaking significant manufacturing, with relevant IP; or well financed, engaged in other businesses, again with relevant IP. Relevant IP protection emerges as a regular feature of success, achieved through an innovators research, networking and collaboration and often spoken of in terms of achievement and professionalism.

The most common feature of the failure of TUI cases was their lack of membership in the networks of finance, government, IP and other businesses, yet often with strong membership in manufacturing. These configurations describe the iconic image of the Kiwi back shed/number 8 wire inventor. The configurations of success speak of the ability of TUI cases to negotiate the complexities of finance, government and regional authorities, intellectual property law, other business activities and – their strength and often the original entree to technological innovation – manufacturing. We will return to discussion of these configurations in the final chapter but will first discuss these configurations and socio-technical networks in greater depth.

Chapter 4
The Context of Innovation

4.1 Introduction: TUI networks and nodes

Fuzzy-set QCA has provided a way to compare across multiple cases of innovation according to their varying participation in socio-technical networks. Pathways in their success or failure are configurational, that is, more than one factor is involved, and overall more than one configuration will exist to both success and failure although we have been able to reduce these two key configurations. This chapter broadens the focus from the core results and considers the context of the cases, that is, the networks themselves and the key nodes within them.

An important influence on this context is New Zealand's innovation governance. Innovation governance refers to the broader institutional context of innovation, comprising the networks of policy, finance, support, mentoring and so on. As noted in the introduction, successive New Zealand governments have attempted to improve the country's relative economic wealth through a variety of strategies with a focus on research, science and technology as a means to innovate within the domestic economy (Ministry of Research, 2008; MoRST, 2008; OECD, 2007; Williams et al., 2008). Summarised in Appendix 1, these policies sustain formal networks which are supplemented by informal networks that coalesce around technologies and what could be termed 'communities of practice'. In effect, these are the means by which innovation governance affects innovation.

This chapter brings the configurations shown by technology users', who are historically and culturally important in innovation in New Zealand, into the broader context of New Zealand's innovation governance. So in reviewing the context of successful innovation we can assess how well this innovation governance is supporting TUI innovations. This will prepare the way for discussions of what our results suggest are the important implications for innovation policy.

4.2 The context of innovation for each key variable

The following sub-sections discuss each of our five variables in ways that show them as part of the socio-technical networks in which TUI cases variously participate.

4.2.1 Capital

As noted in the discussion of capital as a variable, while money is both a useful 'score' on the cost and success of innovation, many TUIs challenged this aspect. The 'power' of money to transform an idea into a prototype, an invention into an innovation, is not disputed. Most case studies used their own income whether savings or credit, including second mortgages. Venture capital and angel investors were not common among our case studies, with most cases struggling to achieve the necessary levels of trust with possible financial backers. As one inventor said:

> *Economics, that's everything. If you can't match the price then forget it…*

Our case studies showed a spread of capital investment ranging from near zero to $1,600,000. Most were self-financed through family firms and farms, emphasising the role that family networks play in this type of innovation, a 'leverage' we consider founded on the significant role of bonding social capital in TUI. This feature is echoed through bridging social capital manifested as support from key people who acted, sometimes informally, to support innovators and their products, especially where merit was seen in the technical utility or contribution to sustainability.

4.2.2 Government support

A regular experience for TUI cases was the difficulty in accessing government help, with several cases claiming there was no help available despite many programmes and initiatives existing. Other innovators reported mixed experiences with regional mentoring programmes and government agencies:

> *…the first thing that happened was he said funding, we can get you some funding for this and that will pay for my time. And I thought 'oh you bastard'. And to me the whole thing is insider! There are consultants there which are creaming it off the Government funding and he said the most I could probably get you is $5000 and I thought it's a joke and of that he was taking $3000 for his advice and at the end of the day he has never sent me an invoice and he doesn't ring me anymore. And I don't ring him.*

> *…the environment has to be free enough so people can still think and if they get bogged down with paper work and bullshit then the thinking is going to go out the door.*

> *Men in suits! I should mention the number of discussions I've had with people offering me expensive advice which is not useful, which consists of a lot of buzz-words but which doesn't touch ground on your particular product.*

> *But it's a lottery in terms of the caliber of what you get, and there are an awful lot of people out there prepared to give you advice which isn't really relevant but charge a great deal of money for it. It's a minefield, it really, really, really is.*

Some inventors could not negotiate the overly complex funding application processes and, valuing their time as a resource that would better serve other tasks – not least the hands-on tinkering that is often their passion – abandoned attempts to garner government funding. Others heard of personal experiences that framed their own approach to seeking funding:

> *…he said [a FRST application] took weeks and weeks trying to get everything together, so that really just put me off.*

We were aware that several of our case studies had negative experiences of school, and discussed these experiences in terms that might nowadays be subject to so-called special needs services (e.g., dyslexia). If we accept that a significant number of New Zealanders suffer from literacy problems,[13] then we would expect that TUIs might be disadvantaged in accessing government and corporate support that requires a very high degree of literacy.

It should be noted that several TUI cases gained invaluable support from employees of government organisations and universities on an informal basis. This was described in terms similar to participation in a 'community of practice' (see Fox, 2000; Wenger, 1998) in which individuals were personally committed to, for example, a more sustainable future and gave their time and skills to projects that satisfied these beliefs. This feature of socio-technical networks reinforces the role of trust and reciprocity many TUI seek and support.

4.2.3 Intellectual property

IP was a controversial topic for many inventors, although most successful cases had undertaken IP protection, usually through a specialist law firm. Distinctions between sectors are apparent, with patents and trademarks less evident in the farming sector and a constant in the energy case studies.

New Zealand's intellectual property legislation was being reviewed at the time of this research. IP, as a variable in our analyses, occurs regularly in successful cases – and its absence is noted in failures – but this is an outcome of networking and learning. The more experienced innovators were often strongly proactive in IP negotiations.

I've locked up all my intellectual property under my own name. And that's the only thing that has kept me alive. Because if I had bolted it into the company we would have gone down the tubes because the next guy, he wanted to dick me over and steal my IP

While some cases were upset by negative experiences, primarily through bad advice (sought through non-specialist lawyers), several cases undertook much of the work with relative ease:

We have taken our own out. [My wife] has actually done it on the net herself.

The Intellectual Property Office of New Zealand sends out an information pack, and I thought, well I can write English, so I set out to patent it myself. And got turned down twice, and after the second time I rang them up and said, I don't want to waste anybody's time, I haven't done this before, should I just flag it away, and hit one particular individual down there who said, no, no, we think it's the best things we've seen for ages. We can't tell you this but we're going to give you a patent. But take it to a patent attorney to draft the claims, it's in your interest. So I did, and she cost me about $1K, and was wonderfully competent.

Others ignored it, one interviewee adhering to Creative Commons principles in making freely available material they published. Others preferred to be quick to market or chose to focus on further technical development:

[13] Chapman, Tunmer, & Allen (2003) found that 7.7 per cent of New Zealand adults self-reported as having a learning disability, with a ratio of males to females of 3:2. Overall, between 40 per cent and 50 per cent of New Zealand adults lack "the minimum level of proficiency required for meeting the complex demands of everyday life in knowledge-based societies".

…we are not big on patents. Most of the products that we produce are small, low-value items and we believe in [being] the first to market, push them out and take what you can at the beginning of the process rather than the cost of a patent.

Do I put $80,000 into development or to put $80,000 into a patent. It wasn't a hard decision in the end but I think the thing is you have to protect yourself from the patent system to a certain extent.

Three of our case studies were aware of 'rip offs'. Two were in farming and were being copied in Australia, a country with which New Zealand has strong historical ties as well as increasingly formalised economic relationships and a certain cultural empathy. The cost of legal action was estimated at $80,000 and $100,000, which both cases dismissed as too much. The third case, a building innovation, was being manufactured and 'subsequently' copied, something the innovator himself did not find remarkable and that he was countering by taking over more of the manufacturing process while still basing manufacture in China.

While IP features strongly in many of the successful TUI configurations, it was difficult to assign it causal status. As noted in the discussion on the energy cases, IP was a standard device to clarify ownership and benefits where collaboration in complex designs and products was common. In other cases, IP seemed to be an ancillary feature, attached to an innovation through advice and an acceptance that protecting IP is a part of being a serious innovator. This was particularly so in the energy sector where most TUIs were engineers trained and experienced in a sector dominated by large companies and complex projects where securing and clarifying IP was standard practice. Those cases that dismissed or disparaged IP did not do so through any ignorance of its function; several owned profitable IP on earlier innovations. For some it was not necessary in a competitive market where speed was the key to success, and IP is, of course, no guarantee of exclusivity.

4.2.4 Manufacturing

While most TUI cases built their own prototypes - indeed this is a central characteristic of a TUI - those cases that persisted in *personally* undertaking a significant amount of the manufacturing often failed. While there are cases of TUI success where most of the manufacturing is 'in-house' this is generally within a small firm owned by the innovator who thus has time and energy for other important innovation tasks.

Those cases that contracted out all or aspects of manufacturing were reliant on a range of other firms. Sometimes one or two other local firms were engaged for components which the TUI person than brought together in the final stages of manufacture (e.g., cases F3 and F11). For simple plastic-extrusion processes, a relatively small firm could be employed. Other times manufacturing was done entirely by a large firm with specialist machinery and skills (e.g., B10, B11).

There are two sorts of suppliers, there are those that say of these guys aren't gonna be around for long, this is a risky business, let's see if we can get as much as we can out of this one job 'cos there won't be anything coming later. And there's the other group who say 'Hmmm, that's an interesting idea, I think they've got a chance here, we'll try support them, do what we can for them, and hopefully it will turn into business in the future.'

Several cases had to import specific materials:

I had to import it [from Korea]. You need to be fairly confident with yourself that you are doing the right thing when you're importing."

Unsurprisingly, several innovations were manufactured in China, with the inventors themselves forging and maintain these cross-border/cross-cultural relationships. One case arranged the necessary introductions and visits via the internet. Regular trips to China were taken by several TUI cases to discuss manufacturing issues and, as one person noted:

They really appreciate the personal contact. Most of their customers they've never met.

Quality was generally very good, an issue of perhaps special importance to TUI people given their strong trade backgrounds and appreciation of good manufacturing.

I have got a very good Chinese engineer, he speaks no English and him and I just solve problems by just drawing pictures, which is quite unique.

But the issue of overseas manufacturing was sensitive to others. Two building cases refused to source manufacturing offshore, wanting to ensure jobs and investment in the local economy:

I get them made in Auckland because I refused to get them made in China, I wouldn't do it there I prefer it to be a New Zealander and I would obviously cut my profit to do that.

Manufacturing is clearly an important consideration in technological innovation. Interestingly, we found that many TUI cases arranged acceptable manufacturing in China and were happy with the technical quality and business relationships. This indicates that concerted efforts to promote New Zealand manufacturing may be somewhat misguided. While we did find examples of technically simple TUI products, such as moulded plastics, being manufactured with ease by small specialist firms, for many technically complicated innovations, Chinese manufacture enabled costs to be kept significantly lower.

A regular observation was that a certain employee or colleague would have exceptional technical skills and contributed with innovations of their own:

I've got a boy out there and he's bright but he can hardly read or write but he's got it up here. And I recognised that as soon as I saw him. He's like me, he's a failure of the school system but he's bright and he's got that ability even now while I am working with him, he can pick things up and he will make suggestions about how we can improve things even beyond me and I like that in a person you know.

4.2.5 Business activities

This aspect of the socio-technical networks of innovation became apparent at an early stage of our research, with several successful innovators establishing other businesses in other areas of interest, including importing and IT services as well as other trades and primary sector businesses. For some innovators, their other businesses provided an income stream that could be used to finance their more experimental work with innovation. For others the networks gave expanded networks of potential support and useful information, not only within the sector they specialised or originated in but across other sectors and into national and regional officialdom.

> *…I'm a carpenter by trade, I was a builder … chucked the building and worked in the bush, went back to the clear felling and its sort have gone on into this. But I had tuna fishing as well, built a boat and did that for about 8 years, coming back every weekend and I got out of that when the store got busy…*

Others expressed some regret at not having developed business skills.

> *It's unfortunate that I never learnt business skills so the inventions have all just been done quietly and I just carried on doing my work and never even thought about promoting it into a business venture*

One feature of business revealed by our interviews was the awareness and sensitivity to ethics. Most cases had experienced what they perceived as incompetency or corruption from others in the networks in which they were participating.

> *…these Jaffas bought it, violated his trust and did the dirty on him … so he said 'right pay me out or I sink it. I don't want to have anything to do with it', so they were on their own. They ended up cutting the company … It was going for less than the stock on hand, less than the raw material … [they] absolutely killed it and somebody else has now got it. It's just a classic case of someone that, I mean the [inventor] was dyslexic, he hasn't got a business bone in his body, he wouldn't know how to write or do anything and yet he could build that amazing business and yet people who supposedly know so much can kill it within a year.*

Many others volunteered instances of dishonesty in their sector, and while it was not possible to prove or disprove these claims, based on our results we confidently assert that societal trust and ethical business practices will facilitate the growth of the social capital that underpins, among other things, TUIs.[14]

[14] In a recent report, Transparency International (2010) found many of New Zealand's largest listed businesses have not achieved fundamental best practice ethics standards. For companies listed on the NZX 50, only 44 per cent have policies prohibiting bribery. This compares to 72 per cent of the UK top 100 companies (by market capitalisation), 57 per cent in Europe, and 69 per cent in the US.

4.2.6 Miscellaneous issues

Several of our case studies were serial inventors, and came up with new ideas and widgets almost compulsively. All learnt over time how to better promote their inventions, that is innovate, although this was no guarantee of success. Our most successful TUI cases were fully aware of marketing methods and utilised modern technologies and the internet to promote themselves and their innovations. Although we found no explicit examples of social networking tools, it is reasonable to expect these successful examples – who are after all well-networked – to access such methods. Many farming case studies did not enjoy reliable internet access, one even having her driveway dug up for a fibre-optic cable which she herself could not access. Government plans to extend broadband access in New Zealand do not aim for universal coverage, a policy that will reinforce the isolation of rural TUIs of whatever sector.

There was a growing awareness of the value in communicating product criteria such as social and environmental qualities as well as personal, family and firm histories. As one case study said:

People love a story.

As is frequently the way, many interviews included, and often ended with, broad observations on tangential issues. Several older interviewees thought their grandchildren did not experience the technological opportunities, and many had experiences of disregard for their skills and invitations:

> *A few years ago we lost our shed in a fire … and I went to [the local] high school where they have work experience for kids and I asked them if they had a kid that was interested in going into the engineering trade, because I've got some work that will teach them some of the skills. And I rang the careers advisor and I never got a reply from them and I was totally disillusioned… I thought to myself 'well maybe schools now are spending too much time with computer and academia rather than teaching basic skills.'*

4.3 Conclusion

The five causal conditions we identified and analysed for their role in innovation by technology users are complex but amenable to fsQCA. Our approach sees each causal condition as a network in which innovators interact with other participants to varying degrees. What the interviews show is a continual struggle to participate effectively in these networks such that their efforts actually promote innovation, even when these networks comprise organisations and resources dedicated to that outcome.

It seems a truism to say that successful innovation requires capital. Obviously, money is needed to develop an invention. What is more pertinent is where this capital is sourced. Our results show that family, often through family farms and firms, provide significant financial support as well as important moral support, and ancillary skills such as administration, promotion and marketing. Perhaps this support could be seen as 'pastoral care'; certainly it is supported by social capital and a key outcome of our research is highlighting the importance of bonding, bridging and organisational capitals to innovation.

Issues of scale are observed in each sector, particularly with New Zealand being seen as too small for many innovations in the building or energy sectors to be successful. Farming innovators, while having a relatively large domestic market, often sought opportunities to sell in Australia or the Americas, particularly the US. New Zealand's innovation system is highly reliant on global links, even at the relatively small-scale of most TUI, and that the sort of expertise, insight and abilities of TUIs – their technological literacy – is a fundamental component of New Zealand's innovation ecology.

Our case studies have revealed remarkably similar experiences whether in farming, building or energy, including simple mass-produced widgets to large-scale and expensive technical systems. Difficulties in accessing the necessary resources, including the correct information and advice, beset all innovators. Many people alluded to different cultural perspectives on technological innovation, including a rural/urban divide, corporate versus family business conflict, and trade or industrial practices versus officialdom and bureaucracy. These insights contributed a great deal to this research, confirmed the usefulness of the innovation ecologies and systems framework, and have helped frame our recommendations.

Chapter 5
Conclusions

5.1 Introduction

The main research objectives of this study were to:

1. Identify the factors causally implicated in the commercial success or failure of technology users who innovate;
2. Document how selective participation in the socio-technical networks surrounding invention affect innovation outcomes;
3. Extend our understanding of innovation within socio-technical networks by proposing a revised model of the TUI network;
4. Make policy recommendations relevant to the effective support of TUI in New Zealand.

A number of cases in the building, farming and energy sectors were identified and studied in detail. The fsQCA method was used to analyse case studies of invention according to their memberships of various networks to identify the configurations by which their success or failure is determined. This method combined both qualitative and quantitative methods, and accepts that more than one configuration to innovation success may exist.

Results show that innovation success was most likely when inventors were:

- Well financed, not undertaking significant manufacturing, and holding relevant IP; or,
- Well financed, engaged in other businesses, again with relevant IP.

The most common configurations leading to innovation failure were when innovators were:

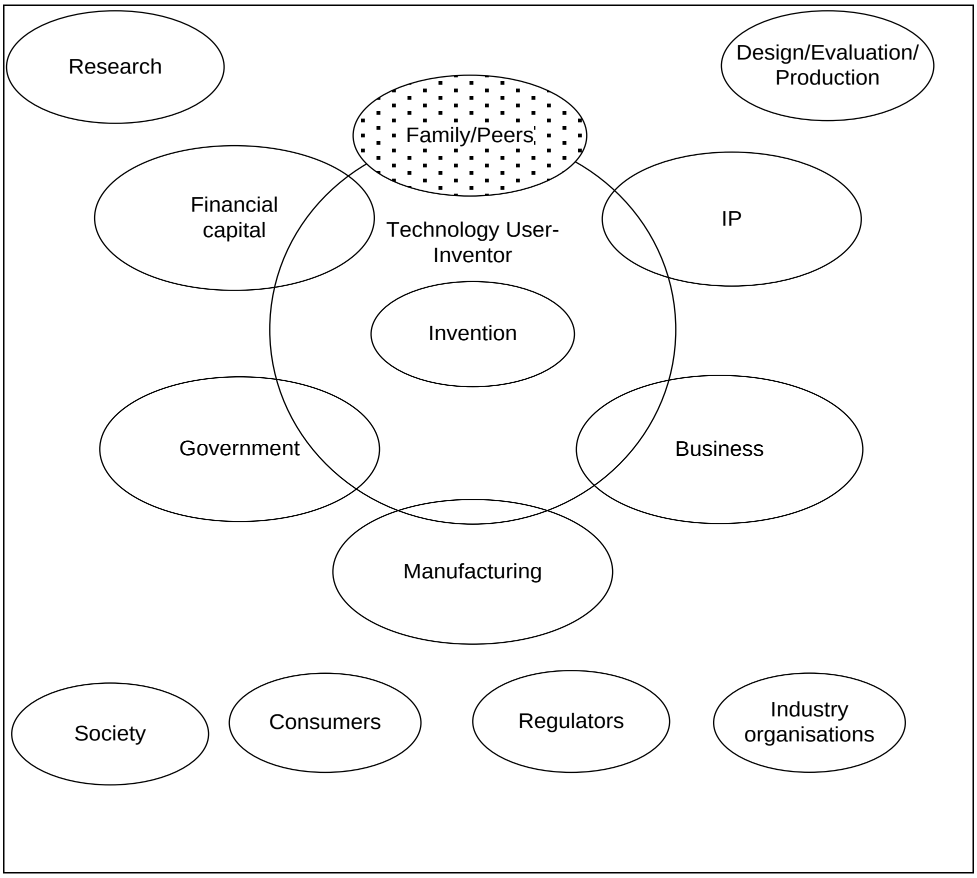
- Poorly financed, lacking government support, not engaged in other business activities, lacking IP; or,
- Well financed, lacking government support, engaged in other businesses, undertaking significant manufacturing, and lacking IP.

This chapter begins by considering the implications for theory. It then considers the implications for policy.

5.2 Core results and their implications for theory

Our results show that successful technology users' innovation requires that inventors manage effectively the wide range of factors surrounding them and their technology. These factors, and the connections between the factors, form a network. Inventors give variable attention to these network connections. Our first TUI model, presented earlier as Figure 1.1, can be improved by including all the observed elements in the network, as shown in Figure 5.1. The figure shows a wide range of key actors (research, design/evaluation/production, society, consumers, regulators, design, and industry organisations) on the periphery of the diagram. These people may not be closely linked to the inventor however they are all interacting with the technology user who mediates between them and the technology. Closer to the centre of the model are the five key factors we have identified as being causally implicated in innovation success (capital, business, government, manufacturing and IP). In addition, the model includes the invention itself, the inventor, and family/peers. Note the lack of causal connections represented by arrows is deliberate and designed to reduce confusion as the model includes many interconnections.

Figure 5.1: Model of the TUI network



Our broad positioning of TUI within society in Figure 1.1 can now be better described through Figure 5.1 above. The model does not explicitly display all of the pathways to successful or unsuccessful innovation as shown by the fsQCA results. In large part this is due to the nature of the results themselves: there is no single pathway to success. So the figure works best by not showing precise pathways but by showing the nature of the network in which the inventor is located. This network has a number of key factors with the most frequent configuration of success involving effectively interacting the five socio-technical networks (capital, government, business, manufacturing and IP). The other success configurations include some but not all of these other factors.

Successful innovation is the product of both individual inventive ability and the ability to manage the factors – the innovation network – within which the invention is developed into an innovation. The results indicate that innovation success is more likely when more of the key factors are given attention. The configurations to failure show that invention by itself is not enough.

While the inventor is the key node of the TUI network - the inventor could be said to 'surround' the invention - this dyad does not exist as an *innovation* without considerable interaction with other nodes. Successful innovation requires the release of this often intensely personal technology so that others may benefit from it. This shows what the key challenge of TUI is: nurture the invention and negotiate for its release so that others want to purchase it. In some cases, new inventions are kept firmly locked within the personal network of the inventor, while in other cases insufficient attention is given to the connections needed to ensure commercial success. The model includes a broad cast of key actors and highlights the potential complexity of the TUI network within which the innovator has to operate.

The model prominently displays the family and peers of the inventor acknowledging the vital role that this plays in successful innovation. This family role is an example of bonding social capital. Of particular importance here is the role of the inventor's spouse. It is well known in farming circles that farm ventures are generally a partnership between husband and wife. In our TUI farming cases, we saw this regularly, commonly with a husband as inventor and wife as 'administrator', and parallels occurred in the other sectors. Administration includes such diverse activities as publicity, website management, meeting with possible collaborators and supporters, and attending mentoring and other programmes. Configurations of innovation success in the farming sector include the presence of business activities. Instead of the classic image of a farming couple squirreling away in the backblocks of rural New Zealand, what we see in successful cases is a well-connected partnership accessing information, support, and capital, often through other business ventures.

In effect, the inventor's social capital plays an important role in mediating the key connections between many of the factors shown in Figure 5.1, whether it is bonding and bridging through family, friends and peers, or wider organisational capital in the performances of other participants in New Zealand's innovation system. The model could be further improved by greater articulation of the dynamics of this social capital and the issues of scale which are important considerations in all sectors. The pathways of success we have observed speak of TUI cases negotiating the complexities of finance, government and regional authorities, intellectual property law, other business activities and – their strength and often the original entree to technological innovation – manufacturing, through the enabling effects of networks of trust, support and respect.

Our results emphasise management of the key factors in the socio-technical networks surrounding invention. This emphasis suggests that the concept of innovation ecologies proposed by Metcalf (2007) has merit. Further conceptual work in this area is needed.

5.3 Core results and their implications for policy

The configurations of success we have identified and discussed could serve as a template by which to judge inventors who may seek increased support, indeed government and private capital undoubtedly have similar models in mind. When asked for policy changes that might assist them in their innovation efforts, many TUIs offered few alternatives, some recoiling from an approach of government 'picking winners' and preferring government to have as little involvement as possible. Most wanted less bureaucracy, hardly a unique request and one that the current government could not be accused of ignoring. However, one fundamental theme from the outset of our research, and highlighted in our fsQCA results, is the importance of financial support. While many case studies sourced personal or family funds for their innovation, most still sought – and would obviously benefit from – further funds through banks, starter funds, government, angel investors and venture capitalists. Other reports have already noted both the importance of financial capital and its relative paucity in New Zealand (Capital Markets Development Taskforce, 2009). Assertions that capital funding for innovation in New Zealand has been increased needs to be interpreted as not being equally available to all inventors because of the difficulties some have in accessing it. While our research coincided with a serious and extensive financial crisis, the *sine qua non* of innovation is financial capital: reducing or eliminating support for innovation in the face of recession can only be counterproductive.

Recommendation 1: That the government investigate opportunities to provide TUIs with financial support. This may include collaboration with the private sector.

Another theme in these results is IP. We know from our case studies that IP protection is now commonly sought as a need for clarity of ownership, assurance to collaborators, and an expression of professionalism and seriousness for an inventor. Yet the processes and outcomes are not always satisfactory. What would help inventors are clear directions at an early stage. While this is something for inventors themselves to accept most responsibility, it does point to a confused context in which IP decisions are made: mistakes have proven costly and difficult to resolve.

Recommendation 2: That the government assist TUIS in learning about best practices for IP management.

The analysis of the innovation governance context of TUI cases shows that a number of factors work against successful innovation. While positive experiences were had by some TUIs, many suffered from incompetent or dishonest individuals; complex processes and documentation, especially in funding applications; and confused policy settings (noted in the energy sector and energy-efficiency aspects of the building sector). Given these factors working against successful innovation, we make the following policy recommendation:

Recommendation 3: That the government modify business support services for TUIS so that they are simpler and have less financial risk for TUIs that use them.

We know from our case studies that innovation is both exceedingly hard work but very satisfying, even rather exciting. But our interviewees spoke of an environment where the prevailing cultural attitudes often work against them. There were three main ways this occurred. First, as fundamentally creative people they believed that the society did not support their creative nature. That **low incentives** exist in New Zealand for 'idea champions', was noted by Gilbertson et al. (1992), as was the 'squashing and control' of creative people. That high personal risk is a feature of innovation is also accepted by TUIs, not least in their commitment of personal savings and business profits to their innovations. Reassuringly, even though TUI people understand the 'tall poppy' syndrome of New Zealand culture, this was never seen as obstructive: most TUI people were so confident in their abilities they are more inclined to think opponents as wrong, even stupid, and work on regardless.

There was also a prevailing sense that participants in the network that they did approach, especially important ones like banks and regulatory agencies, did not readily understand the realities of technological invention. There were strong perceptions by innovators of excessive influence by officials, bureaucrats, accountants and lawyers, particularly within government departments and some of the regional development organisations and incubators. While accepting the biases and prejudices inherent in such communities, we interpret this as a gap in **technological literacy**, the skills, understanding and insight associated with using, manipulating and advancing technologies. Many previous studies (Gilbertson et al., 1995; Gilbertson et al., 1992; Winsley et al., 2001) argue there are difficulties in embedding 'attitude change' in New Zealand innovation governance, a feature of the building and energy sectors that our participants were concerned about.

Third, there was the '**short-termism'** of senior management, also recorded by Gilbertson et al. (1992), that was particularly noticeable in the energy sector, with several cases arguing that the time required for innovations in this area were such that a degree of surety was needed to gain and retain support. Several interviewees spoke of their concerns for the lack of focus and investment in **training** and **apprentice** programmes. Both sectors were undergoing restructuring during our research, although TUI voices are not evident in the political and technical debates that this involves. We would argue this is to the detriment of any sustainable solutions. Others also commented on the education of children and young people, seeing a downgrading of the practical skills that they acquired as children and young people in their fathers' workshops. What would help inventors is wider societal understanding but beyond mere moral support, in fact we use the term 'technological literacy' to define the communication gaps in the struggle technology innovators face in assembling their support.

Recommendation 4: That the government, in its various public awareness initiatives to highlight the importance of innovation, raise the public profile of TUIs by making explicit reference to them.

Another theme in these results is involvement in other businesses. We know from our case studies that this provides experience and contacts that are highly relevant for addressing the challenges which inventors face as they bring their invention to market. While innovators have many opportunities to engage in other business activities, the supportive operation of these activities requires a broader business climate of efficiency, trust, and competence, and we would argue this goes beyond the current review of the Securities Act (Wilson, 2004). Many of our case studies expressed strong cynicism towards government and large corporate interests in their reluctance to innovate due to vested interests in the status quo.

Recommendation 5: That the government investigates the main barriers to good trust relationships between TUIs and other businesses and identify options to improve them.

With other business activities being such a key component of TUI success, policies and support for small-to-medium sized businesses in New Zealand is an area in which the TUI community would obviously benefit. Also, with the husband/wife partnerships identified as integral to many TUI stories, and the obviously heavy workload that these couples take on when they attempt to launch an innovation, policies that ease this workload and minimise the costs and requirements of this reporting, would be of great benefit.

The most common feature of the failure of TUI cases was their lack of membership in the networks of finance, government, IP and other businesses, yet with strong membership in manufacturing. These features describe the iconic image of the Kiwi back shed/number 8 wire inventor. There needs to be ways to encourage inventors to get out of the shed. But for many this goes against the grain. Innovation clubs, websites, mentoring services, help desks, competitions, all exist and often provide excellent support.

Recommendation 6: That the government investigate barriers to TUIS participating in business networks, with a view to identifying options to support such networks and TUIS participation in them. In particular, there is a need for a government supported website to facilitate inventor engagement in their socio-technical networks.

The **small size** of the New Zealand market was a constant constraint in the building sector:

> *You are jammed up against it, you know that to provide it for x amount of money you have to run off 50,000, 100,000… but the shops are saying listen we will put a dozen in and see how they go. You can't put a dozen in without buying 100,000, at that point you realise that you are dealing with a small country.*

One case study noted that if he sold one of his product to each builder in New Zealand, that would amount to about 1,400 sales it would just about cover his costs. He needed to export but had misread the Australian market and was now looking at the US. An interview with a building company representative illustrated New Zealand's reliance on international technology in the sector, with strategies of overseas searches by 'technology tourists' for innovations. As noted in the literature review, innovation systems are global entities.

Recommendation 7: That the government investigate and address the main barriers to TUIs participating in its initiatives to connect New Zealand innovators with foreign business networks.

The role of the Building Research Association of New Zealand (BRANZ) – an independent research company – is central to many innovators in the building sector. Funded via a levy on building consents, through FRST, and by revenues generated through commercial research projects, BRANZ's key role for innovators is the provision of appraisals, 'independent assessments of building products, materials, systems or methods of design or construction'.[15] However, operating as a 'cost recovery' agency, many innovators participating in this process see it as a 'grudge purchase'.

The role of regulatory authorities such as BRANZ and the city and district councils was considered a serious drag on innovation due to the costs and time lags involved. For several cases, these constraints were nominated as the reason why their innovation had either failed or was yet to succeed. Representatives of BRANZ acknowledged many clients resented the role of BRANZ, whose appraisal was necessary to negotiate the array of authorities who would otherwise each require assurance of the safety and reliability of the innovators' claims. In one case study the inventor themselves took part in the testing process to save time and money; this may be an approach that BRANZ could formalise and encourage for smaller innovators like TUIs who have great technical abilities and a strong desire to minimise costs and delays.

Recommendation 8: That the government investigate more flexible arrangements to simplify and streamline the compliance of TUIs with regulatory approval procedures.

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[15] See http://www.branz.co.nz/cms_display.php

As we noted earlier, finding cases of TUI in the energy sector was more difficult than in farming of building. While all three sectors have their technical challenges, it might be argued the **energy sector epitomises the difficulties in technological innovation**, with many years training and work experience behind those who even attempt an energy innovation. Much of the paraphernalia of this sector – tools, workshop facilities, and specialised materials – are often expensive. TUI cases in this sector were more likely to be familiar with, and possess, IP, as it is more common within the sector as a whole and where innovators need to collaborate, potential partners generally require a clear delineation of who owns what.

Recommendation 9: That the government support the establishment of an innovation centre that draws together the technological skills and insights of TUI.

It is clear to us that the Kiwi backshed inventors are more sophisticated and can potentially contribute more to New Zealand's economic growth – as they have in the past – yet they require more practical help than is evident. As human and social capital, these inventors/innovators are well-placed to contribute to technology policy, education and regional development yet too often exist as isolated small-business people instead of the resilient contributors to the innovation ecology of the country.

5.4 Conclusion

Innovation by technology users is an important cultural component of New Zealand's historical development and contemporary perceptions. This type of innovation continues, particularly in farming but with significant efforts in the building and energy sectors. But this community of innovators is also clearly struggling with an innovation governance context in which access to capital, sympathetic and relevant support, and accurate information is limited. Successful TUI cases are adept at sourcing information and support but the costs and efforts to do this are considerable and even excessive as TUIs draw on valuable social capital while undertaking many of the necessary ancillary tasks themselves.

A lack of technological literacy among participants in the necessary networks is an obstacle to innovation. Such literacy seems to be on the decline as fewer New Zealanders work and train in the trades. Coupled with this is the decline in New Zealand's manufacturing base although we note the successful self-directed engagement with Chinese manufacturing that several case studies demonstrated. Many cases also noted the lack of faith they now had in officials through the poor performance and actions of particular individuals, and the lack of clear strategic direction from the relevant Ministries. For technology experts such as the innovators we interviewed, ignorance, incompetence or dishonesty in officials was very disheartening and always tainted available options.

Despite these concerns, all of our successful cases benefitted from instances of informal information exchange with supportive and knowledgeable participants, often people with particular technological interests themselves. This aspect emphasises social capital and its role in providing financial capital and other resources for innovation through families, family-owned businesses, and committed networks for innovation.

References

Akrich, K., Callon, M., & Latour, B. (2002). The Key to Success in Innovation Part 1: The art of interessement. *International Journal of Innovation Management, 6*(2), 187-206.

Backhaus, J. (Ed.). (2003). *Joespeh Alois Schumpeter: Entrepreneurship, Style and Vision*: Kluwer Academic Publishers.

Bridges, J., & Owens, D. (2000). *No. 8 Wire: The best of Kiwi Ingenuity*. Auckland: Hodder Moa.

Capital Markets Development Taskforce. (2009). *Capital markets matter*. Wellington: Ministry of Economic Development.

Cathcart, B. (2004). *The fly in the cathedral : how a small group of Cambridge scientists won the race to split the atom*. London: Viking.

Chapman, J. W., Tunmer, W. E., & Allen, R. (2003). Findings from the International Adult Literacy Survey on the incidence and correlates of learning disabilities in New Zealand: Is something rotten in the state of New Zealand? *Dyslexia, 9*(2), 75-98.

Crocombe, G. T., Enright, M. J., & Porter, M. E. (1991). *Upgrading New Zealand's Competitive Advantage*. Oxford: Oxford University Press.

Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy, 11*, 147-162.

Drew, A. (2007). *New Zealand's productivity performance and prospects*. Wellington: Reserve Bank of New Zealand. Retrieved from http://www.rbnz.govt.nz/research/bulletin/2007_2011/2007mar70_1drew.pdf

Dvir, R., & Pasher, E. (2004). Innovation engines for knowledge cities: An innovation ecology perspective. *Journal of KnowledgeMmanagement, 8*(5), 16-27.

Easton, B. (1997). *In Stormy Seas: The Post-War New Zealand Economy*. Dunedin: University of Otago Press.

Fagerberg, J., & Verspagen, B. (2009). Innovation studies: The emerging structure of a new scientific field. *Research Policy, 38*, 218-233.

Firkin, P. (2001). *'Doing the books': Social capital between spouses in business-owning families*. Palmerston North: Labour market dynmaics research programme. (Working Paper no. 6)

Fiss, P. (2008). Configurations of strategy, structure and environment: A fuzzy set analysis of high technology firms. Retrieved from http://www-rcf.usc.edu/~fiss/research.html

Fox, S. (2000). Communities Of Practice, Foucault And Actor-Network Therory. *Journal of Management Studies, 37*(6), 853-868.

Galbreath, R. (1998). *Making Science Work for New Zealand*. Wellington: Victoria University Press.

Gallagher Group. (2008). *Gallagher Group*. Retrieved from http://www.gallaghergroup.co.nz/history.aspx

Garud, R., & Karnoe, P. (2003). Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. *Research Policy, 32*, 277-300.

Gertler, M. S. (2003). Tacit Knowledge and the economic geography of context, or The undefinable tacitness of being (there). *Journal of Economic Geography, 3*, 75-99.

Gertler, M. S., & Levitte, M. (2005). Local nodes in global networks: the geography of knowledge flows in biotechnology innovation. *Industry and Innovation, 12*(4), 487-507.

Gibbons, M., & Johnston, R. (1974). The Roles of Science in Technolgical Innovation. *Research Policy, 3*(3), 221-242.

Gilbertson, D. W., Gilbertson, D., Knight, R. M., & Wright, H. (1995). *Innovation and management : New Zealand case studies* (Vol. 2). Palmerston North: Dunmore Press.

Gilbertson, D. W., Knight, R. M., Kukutai, A., & Cooper, A. (1992). *Innovation and management in New Zealand : a casebook*. Palmerston North: Dunmore Press.
Gluckman, P. (2009). Speech to Massey University. Massey University.
Godin, B. (2003). *The most cherished indicator: Gross Domestic Expenditures on R&D (GERD)*. Montreal: Institut national de la recherche scientifique. (Working Paper No. 22)
Grabher, G., Ibert, O., & Flohr, S. (2008). The neglected king: The customer in the New Knowledge Ecology of Innovation. *Economic Geography, 84*(3), 253-281.
Hamilton Jet. (2009). *Hamilton Jet*. Retrieved June 5th, 2009, from http://www.hamiltonjet.co.nz/home
Hellman, T., & Puri, M. (2002). Venture capital and the professionalization of start-up firms: Empirical evidence. *The Journal of Finance, 57*(1), 169-197.
Hendy, S. (2009). The MacDiarmid Institute Challenge. *Interface*(14), 12-13. Retrieved from www.macdiarmid.ac.nz
Henrich, J. (2001). Cultural transmission and the diffusion of innovations: adoption dynamics indicate that biased cultural transmission is the predominant force in behavioral change. *American Anthropologist, 103*(4), 992-1014.
Hofstede, G. (1984). *Culture's Consequences: International Work-Related Values* (Abridged Ed. ed.). Beverly Hills: Sage Publications.
Hogan, D., & Williamson, B. (Eds.). (1999). *New Zealand is Different: Chemical Milestones in New Zealand history*. Christchurch: Clerestory Press.
Hopkins, J. (1998). *Blokes and sheds*. Auckland: HarperCollins.
Hopkins, J. (1999). *Inventions from the shed*. Auckland: HarperCollins.
Hopkins, J. (2002). *Back in the shed*. Auckland: HarperCollins.
Hopkins, J. (2004). Backyard Genius: Snap - a sheep is caught and a dog is warm. *New Zealand Herald*. Retrieved from http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=9004753
Hussler, C. (2004). Culture and knowledge spillovers in Europe: New perspectives for innovation and convergence policies? *Economics of Innovation and New Technology, 13*(6), 523 - 541.
Intellectual Property Office of New Zealand. (2009, 12 December 2008). *IPONZ - Intellectual Property Office of New Zealand*. Retrieved June 5th, 2009, from http://www.iponz.govt.nz/cms
Johnston, R. (1991). *Technology Strategy in New Zealand Industry*. Wellington: Ministry of Research, Science, and Technology.
Kay, J. (2010). *Obliquity: why our goals are best achieved indirectly*. London: Profile Books.
Kelsey, J. (1995). *The New Zealand Experiment: a world model for structural adjustment?* (1st ed.). Auckland: Auckland University Press.
Kline, S., & Rosenberg, N. (1986). An overview of innovation. In R. Landau & N. Rosenberg (Eds.), *The Positive Sum Strategy* (pp. 275-304). Washington D.C.: National Academy Press.
Landry, R., Amara, N., & Lamari, M. (2002). Does social capital determine innovation? To what extent? *Technological Forecasting and Social Change, 69*(7), 681-701.
MacKenzie, D., & Wajcman, J. (Eds.). (1999). *The Social Shaping of Technology* (2nd ed.). Buckingham: Open University Press.
McCann, P. (2009). Economic geography, globalisation and New Zealand's productivity paradox. *New Zealand Economic Papers, 43*(3), 279 - 314.
Metcalfe, S. (2007). Innovation systems, innovation policy and restless capitalism. In F. Malerba & S. Brusoni (Eds.), *Perspectives on innovation* (pp. 441-454). Cambridge: Cambridge University Press.
Mill, J. S. (1848). *Principles of Political Economy: With Some of Their Applications to Social Philosophy*. London: J.W. Parker.

Ministry of Research, S., and Technology,. (2008). *Evaluation of the R&D tax credit - Baseline Study 1 Part A: How ready are New Zealand firms for the R&D tax credit?* Wellington: Ministry of Research, Science, and Technology.
Ministry of Research, S., and Technology,. (2010). *Igniting potential: New Zealand's science and innovation pathway*. Wellington.
Morgan, K. (2004). The exaggerated death of geography: learning, proximity and territorial innovation systems. *Journal of Economic Geography, 4*(1), 3-21.
MoRST. (2008). *Research and Development in New Zealand: 2008*. Wellington: Ministry of Research, Science, and Technology.
New Zealand Institute. (2009). *New Zealand's innovation ecosystem - emerging conclusions*. Auckland: New Zealand Institute. Retrieved from http://www.nzinstitute.org/Images/uploads/NZs_innovation_ecosystem_-_emerging_conclusions.pdf
OECD. (2007). *OECD Reviews of Innovation: New Zealand*. Paris: Organisation for Economic Co-operation and Development. Retrieved from www.sourceoecd.org/scienceIT/9789264037601
OECD. (2009). OECD Economic Surveys: New Zealand 2009. *OECD Economic Surveys, 2009*(4), 1-151.
Perry, M. (2001). Shared trust in small industrial countries: an evaluation from New Zealand. *Norsk Geografisk Tidsskrift/Norwegian Journal of Geography, 55*, 1-8.
Proudfoot, I. (2010). *KPMG agribusiness agenda: The big opportunities and challenges facing New Zealand agriculture: Reflections of the views of industry leaders.* Auckland: KPMG.
Putnam, R. (2000). *Bowling Alone: The collapse and revival of American community*. New York: Simon and Schuster.
Ragin, C. (1987). *The Comparative Method: Moving beyond qualitative and Quantitative Strategies*. Berkely: University of California Press.
Ragin, C. (2000). *Fuzzy-Set Social Science*. Chicago: University of Chicago Press.
Ragin, C. (2008). *Redesigning Social Inquiry: Fuzzy Sets and beyond*. Chicago: University of Chicago Press.
Ragin, C. (2008). *Redesigning Social Inquiry: Set relations and social research*. Chicago: University of Chicago Press.
Ragin, C., & Sonnett, J. (2004). Between Complexity and Parsimony: Limited Diversity, Counterfactual Cases, and COmparative Analysis. In S. Kropp & M. Minkenberg (Eds.), *Vergleichen in der Politikwissenschaft*. Wiesbaden: VS Verlag fur Sozialwissenschaft.
Rapp, F. (1981). *Analytical Philosophy of Technology* (S. R. Carpenter & T. Langenbruch, Trans., Vol. 63). Dordrecht: D. Reidel Publishing Company.
Rihoux, B., & Ragin, C. (Eds.). (2009). *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques*. Los Angeles: Sage.
Rizova, P. S. (2007). *Applying Charles Ragin's Method of Qualitative Comparative Analysis (QCA) to the Study of Technological Innovation*: SSRN.
Rogers, E. (2005). *Diffusion of Innovations* (5th ed.). New York: Free Press.
Rogers, E., & Scott, K. L. (1997). The Diffusion of Innovations Model and Outreach from the National Network of Libraries of Medicine to Native American Communities. [Draft paper prepared for the National Network of Libraries of Medicine, Pacific Northwest Region, Seattle.].
Rogers, E., & Shoemaker, F. F. (1971). *Communication of Innovations: A Cross-cultural Approach* (2nd ed.). New York: The Free Press.
Romer, P. M. (1990). Endogenous Technological Change. *The Journal of Political Economy, 98*(5), S71-S102.

Rothwell, R., Freeman, C., Horsley, A., Jervis, V. T. P., Robertson, A. B., & Townsend, J. (1974). SAPPHO updated: project SAPPHO phase II. *Research Policy, 3*, 258-291.
Rutten, R., & Boekema, F. (2007). Regional social capital: Embeddedness, innovation networks and regional economic development. *Technological Forecasting and Social Change, 74*(9), 1834-1846.
Saunders, C., Dalziel, P., & Kaye-Blake, W. (2009). *Economic strategy issues for the New Zealand region in the global economy* (No. 317). Christchurch: Agribusiness and Economics Research Unit. Retrieved from http://www.lincoln.ac.nz/PageFiles/1494/RR%20317w.pdf
Sismondo, S. (2004). *An Introduction to Science and Technology Studies*. Oxford: Blackwell.
Smale, T. (2009). *Playing to our strengths*. Wellington: NZ Trade and Enterprise.
Smith, K. (2005). Measuring Innovation. In I. Fagerberg, D. C. Mowery & R. R. Nelson (Eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.
Smith, K. (2006). *Public Policy Framework for the New Zealand Innovation System*. Wellington: Ministry of Economic Development.
Smits, R. (2002). Innovation studies in the 21st century;: Questions from a user's perspective. *Technological Forecasting and Social Change, 69*(9), 861-883.
Svendsen, G. L. H., & Sorensen, J. F. L. (2007). There's more to the picture than meets the eye: Measuring tangible and intangible capital in two marginal communities in rural Denmark. *Journal of Rural Studies, 23*, 453-471.
The Listener. (2010). All things being equal. *The Listener, May 1-7*, 14-21.
Transparency International. (2010). *Are we as good as perceived? A review of the approach to bribery and corruption by New Zealand business*. Wellington: Transparency International.
Valliere, D., Ni, N., & Wise, S. (2008). Prior Relationships and M&A Exit Valuations: A Set-Theoretic Approach. [Retrieved June 10, 2009, from ABI/INFORM Global database. (Document ID: 1553920031).]. *The Journal of Private Equity, 11*(2), 60-72.
van Wyk, L. (2009). *TUANZ Rural Broadband Symposium*. Auckland: Telecommunications Users Association of New Zealand. Retrieved from http://www.tuanz.org.nz/news/c2162dbf-0b24-4855-8bd5-802b93ffdd85.html?PathId=cae7268c-913b-463c-8e7a-6f697b075142
von Hippel, E. (1976). The dominant role of users in the scientific instrument innovation process. *Research Policy, 5*(3), 212-239.
von Hippel, E. (1988). *The Sources of Innovation*. New York: Oxford University Press.
Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.
Williams, J., Debski, I., & White, R. (2008). *Business Expenditure on Research and Development in New Zealand: Future potential and future industries*. Wellington: Ministry of Research, Science, and Technology.
Wilson, M. (2004). Government's role in regulating the financial services industry: Speech to Financial Planners and Insurance Advisers Association (Christchurch Branch), Christchurch. Retrieved from http://www.med.govt.nz/templates/Page____16725.aspx
Winsley, P. (1997). *A Study of Technological Innovation in New Zealand*. Victoria, Wellington.
Winsley, P., Gilbertson, D., & Couchman, P. (2001). *Managing Innovation in New Zealand*. Palmerston North: Dunmore Press.
Wulf, W. (2007). Changes in innovation ecology. *Science, 316*(5829), 1253.
Yandle, B. (2010). Lost trust: The real causes of the financial meltdown. *Independent Review, 14*(3), 341-361.

Appendix 1
Government funding initiatives

Policy agencies: Ministry of Economic Development, Ministry of Research, Science and Technology, Ministry of Agriculture and Forestry (Sustainable Farming Fund).

Policies and instruments: FRST, Road Maps for Science (Energy, Nanoscience and Nanotechnologies, Biotechnology and Environment).

Government implementers: Foundation for Research, Science, and Technology (FRST), NZ Trade and Enterprise, Energy Efficiency and Conservation Authority (EECA), LGNZ and Local Economic Development Agencies, Business New Zealand, New Zealand Venture Investment Fund Limited.

Investment tools: Venture Capital Investment Fund, E-Business Guide, New Zealand Investment Network, Incubators New Zealand, Industry Capability Network, Business Mentors New Zealand, New Zealand Private Equity and Venture Capital Association, New Zealand Angels, Movac, Vcapital, Homebizz Buzz, Bio Pacific Ventures, Endeavour Capital, Finistere, AgResearch, Connect New Zealand, Pacific Business Trust, Life Wise - The Employment Generation Fund, The Tindall Foundation, and Poutama Business Trust.

Appendix 2
Interview Schedule

Name of Project: Technology Users' Innovation (TUI)

You are invited to participate in the TUI project by completing the following questionnaire.

The aim of the project is *to examine the social setting of innovation and unpack the specific socio-technical networks to see what is helping or hindering the commercialisation process. This can be achieved by comparing successful and unsuccessful cases, so even if your innovation is not commercially successful, it will still provide important information on how to understand and navigate New Zealand's innovation networks.*

1. *How did this innovation come about?*

2. *What is different about this innovation?*

3. *What is your target market?*

4. *Describe your employment and business activities.*

   How many people do you employ?

5. *Do you consider yourself an inventor? Businessperson? Do you think you are an 'outsider'?*

6. *Who helps you?*
   a. *Friends, family and/or neighbours*
   b. *How much of the construction or manufacturing processes can you undertake on your own?*
   c. *Collaboration with universities or CRIs*
   d. *Do you have a partnership with any private companies?*
   e. *Government advisors?*
   f. *Private consultants?*

7. *How are you financed?*
   a. *Are your solely reliant on your own money?*
   b. *Have you borrowed? Who from?*
   c. *Do you have access to government funding?*
   d. *Are you partly supported by private companies?*

8. *What stage of the innovation process do you think you're at?*

9. *When did you consider innovation this successful?*

10. *Are you doing your own marketing? If so, what are the results?*

11. *What policy changes would help you?*
    a. *Changes to regulations? (e.g., local council bylaws)*
    b. *Changes in legislation? (e.g., RMA).*
    c. *Better government policy?*

12. *Have you taken out any patents, licenses, or copyright applications?*

Appendix 3
Overall Success

This and subsequent appendices reproduce the results of fsQCA using the software package fsQCA 2.2 (released January, 2009), derived from Table 3.1. Included are the tables showing the distribution of TUI cases across the causal combinations and the set-theoretic consistency of these combinations as subsets of ‘success’ and ‘failure’ (technically non-success) for each of the three sector we have investigated.

Recall that **Raw coverage** refers to the proportion of memberships in the outcome explained by each term of the solution. **Unique coverage** measures the proportion of memberships in the outcome explained *solely* by each individual solution. **Consistency** is a measure of the degree to which membership in each solution term is a subset of the outcome. **Solution coverage** measures the proportion of memberships in the outcome that is explained by the complete solution. **Solution consistency** measures the degree to which membership in the solution (the set of solution terms) is a subset of membership in the outcome.

From this table we can see how complex innovation configurations are, with no less than nine distinct configurations to innovation success recorded from our case studies although as Table 1 shows five of these configurations have just a single empirical example among our case studies. Following the table are results showing the complex, parsimonious and intermediate solutions that stem from the set of fsQCA software, and are offered to give greater insight into our data.

Table 1: Truth table for overall success

CAPITAL	GOVT	BIZ	MANU	IP	number	success	consist
0	0	1	0	1	1	1	1
1	1	0	0	1	1	1	1
1	1	1	0	1	5	1	1
0	0	1	0	0	1	1	1
1	0	1	1	1	5	1	0.984252
0	1	0	1	1	1	1	0.943396
1	0	0	0	1	3	1	0.890351
1	1	1	1	1	9	1	0.872781
0	1	0	1	0	1	1	0.867188
1	0	1	0	1	4	-	0.840399
0	1	1	1	0	2	0	0.595331
1	0	1	1	0	2	0	0.548544
0	0	0	1	1	1	0	0.528634
0	0	0	0	0	2	0	0.292035
0	0	0	1	0	5	0	0.234801

n=2

Complex Solution
frequency cutoff: 2.000000; consistency cutoff: 0.872781

	raw coverage	unique coverage	consistency
CAPITAL*GOVT*BIZ*IP	0.368421	0.129555	0.898322
CAPITAL*MANU*BIZ*IP	0.390688	0.151822	0.912961
CAPITAL*govt*manu*biz*IP	0.082186	0.082186	0.890351

solution coverage: 0.602429
solution consistency: 0.917386

Parsimonious Solution
frequency cutoff: 2.000000; consistency cutoff: 0.872781

	raw coverage	unique coverage	consistency
IP	0.899595	0.899595	0.804781

solution coverage: 0.899595
solution consistency: 0.804781

Intermediate Solution
frequency cutoff: 2.000000; consistency cutoff: 0.872781
Assumptions: BIZ, GOVT, and CAPITAL present.

	raw coverage	unique coverage	consistency
CAPITAL*MANU*IP	0.451822	0.115790	0.926141
CAPITAL*BIZ*IP	0.604049	0.268016	0.893413

solution coverage: 0.719838
solution consistency: 0.897527

n=1

Complex Solution
frequency cutoff: 1.000000; consistency cutoff: 0.867188

	raw coverage	unique coverage	consistency
capital*govt*BIZ*manu	0.141296	0.097571	0.991477
capital*GOVT*biz*MANU	0.055466	0.046964	0.769663
CAPITAL*biz*manu*IP	0.115789	0.082186	0.919614
CAPITAL*BIZ*MANU*IP	0.390688	0.108097	0.912961
CAPITAL*GOVT*manu*IP	0.233198	-0.000000	1.000000
CAPITAL*GOVT*BIZ*IP	0.368421	0.005263	0.898322

solution coverage: 0.780567
solution consistency: 0.915480

Parsimonious Solution
frequency cutoff: 1.000000; consistency cutoff: 0.867188

	raw coverage	unique coverage	consistency
GOVT*biz	0.080972	0.044939	0.666667
CAPITAL*IP	0.732794	0.338057	0.892505
BIZ*manu	0.441296	0.043725	0.837174
capital*govt*BIZ	0.170445	0.006478	0.884454

solution coverage: 0.889474
solution consistency: 0.809208

Intermediate Solution
frequency cutoff: 1.000000; consistency cutoff: 0.867188
Assumptions: BIZ (present) GOVT (present) CAPITAL (present)

	raw coverage	unique coverage	consistency
BIZ*manu	0.441296	0.105263	0.837174
GOVT*MANU*biz	0.055466	0.046964	0.744565
CAPITAL*manu*IP	0.451822	0.107288	0.926141
CAPITAL*BIZ*IP	0.604049	0.268016	0.893413

solution coverage: 0.872065
solution consistency: 0.844044

Appendix 4
Overall Failure

Table 2: Truth table for overall failure

CAPITAL	GOVT	BIZ	MANU	IP	number	success	consist
0	0	0	1	1	1	1	1
0	0	0	1	0	5	1	1
0	0	0	0	0	2	1	1
1	0	1	1	0	2	1	0.917476
0	1	1	1	0	2	1	0.879377
0	1	0	1	1	1	0	0.754717
0	1	0	1	0	1	0	0.710938
0	0	1	0	1	1	0	0.631769
0	0	1	0	0	1	0	0.600000
1	0	1	0	1	4	0	0.588529
1	0	0	0	1	3	0	0.495614
1	1	1	1	1	9	0	0.464497
1	1	1	0	1	5	0	0.403651
1	0	1	1	1	5	0	0.293963
1	1	0	0	1	1	0	0.289157

n=2
Complex Solution
frequency cutoff: 2.000000; consistency cutoff: 0.879377

	raw coverage	unique coverage	consistency	
capital*govt*biz*ip		0.338251	0.338251	1.000000
CAPITAL*govt*BIZ*MANU*ip	0.103279	0.103279	0.917476	
capital*GOVT*BIZ*MANU*ip	0.123497	0.123497	0.879377	

solution coverage: 0.565027
solution consistency: 0.955638

Parsimonious Solution
frequency cutoff: 2.000000; consistency cutoff: 0.879377

	raw coverage	unique coverage	consistency
ip	0.705465	0.640437	0.838856
govt*BIZ*manu	0.153552	0.088525	0.431644

solution coverage: 0.793989
solution consistency: 0.723966

Intermediate Solution
frequency cutoff: 2.000000; consistency cutoff: 0.879377
Assumptions: BIZ (absent) GOVT (absent) CAPITAL (absent)

	raw coverage	unique coverage	consistency
ip*MANU*capital	0.494536	0.173224	0.915066
ip*MANU*govt	0.392350	0.071038	0.956059
ip*biz*govt*capital	0.338251	0.077596	1.000000

solution coverage: 0.643169
solution consistency: 0.920970

n=1
Complex Solution
frequency cutoff: 1.000000; consistency cutoff: 0.879377

	raw coverage	unique coverage	consistency	
capital*govt*biz*ip		0.338251	0.077596	1.000000
capital*govt*biz*MANU	0.304918	0.044262	0.942568	
CAPITAL*govt*BIZ*MANU*ip	0.103279	0.103279	0.917476	
capital*GOVT*BIZ*MANU*ip	0.123497	0.123497	0.879377	

solution coverage: 0.609290
solution consistency: 0.931495

Parsimonious Solution
frequency cutoff: 1.000000; consistency cutoff: 0.879377

	raw coverage	unique coverage	consistency
capital*govt*biz	0.415301	0.415301	0.914561
BIZ*MANU*ip	0.296721	0.296721	0.855118

solution coverage: 0.712022
solution consistency: 0.888813

Intermediate Solution
frequency cutoff: 1.000000; consistency cutoff: 0.879377
Assumptions: BIZ, GOVT, and CAPITAL present.

	raw coverage	unique coverage	consistency
capital*govt*biz*ip	0.338251	0.077596	1.000000
capital*govt*biz*MANU*	0.304918	0.044262	0.942568
GOVT*BIZ*MANU*ip*	0.165027	0.060109	0.836565
CAPITAL*BIZ*MANU*ip*	0.208197	0.103279	0.833698

solution coverage: 0.650820
solution consistency: 0.915450

Appendix 5
Farming success

Table 3: Farming success truth table

CAPITAL	IP	MANU	BIZ	GOVT	number	success	consist
1	1	0	1	1	1	1	1
1	1	1	1	1	3	1	1
0	0	0	1	0	1	1	1
0	1	0	1	0	1	1	1
1	1	1	1	0	2	1	0.980263
0	1	1	0	1	1	1	0.909091
0	0	1	1	1	1	0	0.51282
1	0	1	1	0	1	0	0.359551
0	0	0	0	0	1	0	0.2
0	0	1	0	0	4	0	0.181269

Complex Solution
frequency cutoff: 1.000000; consistency cutoff: 0.909091

	raw coverage	unique coverage	consistency
capital*manu*BIZ*govt	0.235366	0.168293	0.984694
CAPITAL*IP*MANU*BIZ	0.446341	0.114634	0.991870
CAPITAL*IP*BIZ*GOVT	0.307317	0.042683	1.000000
capital*IP*MANU*biz*GOVT	0.073171	0.073171	0.909091

solution coverage: 0.730488
solution consistency: 0.980360

Parsimonious Solution
frequency cutoff: 1.000000; consistency cutoff: 0.909091

	raw coverage	unique coverage	consistency
IP	0.875610	0.513415	0.876679
manu*BIZ	0.376829	0.000000	0.922388
capital*BIZ*govt	0.307317	0.015854	0.890459

solution coverage: 0.962195
solution consistency: 0.856677

Intermediate Solution
frequency cutoff: 1; consistency cutoff: 0.909091 Assumptions: BIZ GOVT and CAPITAL present.

	raw coverage	unique coverage	consistency
manu*BIZ	0.376829	0.178049	0.922388
MANU*IP*GOVT	0.376829	0.108537	0.962617
BIZ*IP*CAPITAL	0.489024	0.108537	0.992574

solution coverage: 0.779268
solution consistency: 0.939706

Appendix 6
Farming failure

Table 4: Farming Failure Truth Table

CAPITAL	IP	MANU	BIZ	GOVT	number	success	consist
0	0	1	0	0	4	1	1
0	0	0	0	0	1	1	1
1	0	1	1	0	1	1	0.966292
0	0	1	1	1	1	1	0.880342
1	1	0	1	1	1	0	0.88
0	1	1	0	1	1	0	0.606061
0	0	0	1	0	1	0	0.448276
1	1	1	1	1	3	0	0.419355
0	1	0	1	0	1	0	0.385185
1	1	1	1	0	2	0	0.210526

Complex Solution
frequency cutoff: 1.000000; consistency cutoff: 0.880342

	raw coverage	unique coverage	consistency	
capital*ip*biz*govt		0.519231	0.519231	1.000000
CAPITAL*ip*MANU*BIZ*govt	0.110256	0.110256	0.966292	
capital*ip*MANU*BIZ*GOVT	0.132051	0.132051	0.880342	

solution coverage: 0.761538
solution consistency: 0.972177

Parsimonious Solution
frequency cutoff: 1.000000; consistency cutoff: 0.880342

	raw coverage	unique coverage	consistency
ip*MANU	0.771795	0.303846	0.931889
biz*govt	0.564103	0.044872	0.880000
ip*biz	0.562820	0.000000	1.000000

solution coverage: 0.911538
solution consistency: 0.872393

Intermediate Solution
frequency cutoff: 1.000000; consistency cutoff: 0.880342
Assumptions: MANU (absent) BIZ (absent) CAPITAL (absent)

	raw coverage	unique coverage	consistency
MANU*ip*capital	0.662820	0.175641	0.945155
MANU*ip*govt	0.570513	0.083333	0.965293
biz*ip*govt*capital	0.519231	0.094872	1.000000

solution coverage: 0.841026
solution consistency: 0.956268

Appendix 7
Building success

Table 5: Building success truth table

CAPITAL	IP	MANU	BIZ	GOVT	number	success	consist
1	1	1	0	0	1	1	1
1	1	1	1	0	2	1	1
1	0	1	1	1	3	1	0.985849
1	1	1	1	1	3	1	0.889447
1	0	1	0	0	2	1	0.857143
0	1	0	0	1	1	1	0.819149
1	0	1	1	0	3	-	0.772242
1	0	0	1	1	1	0	0.657143

Complex Solution
frequency cutoff: 1.000000; consistency cutoff: 0.819149

	raw coverage	unique coverage	consistency
CAPITAL*IP*biz*manu	0.189815	0.116667	0.907080
CAPITAL*IP*BIZ*MANU	0.357407	0.193518	0.939173
capital*GOVT*ip*biz*MANU	0.071296	0.055555	0.819149
CAPITAL*GOVT*IP*manu	0.296296	-0.000000	1.000000
CAPITAL*GOVT*IP*BIZ	0.337037	0.012037	0.903226

solution coverage: 0.775926
solution consistency: 0.912854

Parsimonious Solution
frequency cutoff: 1.000000; consistency cutoff: 0.819149

	raw coverage	unique coverage	consistency
IP	0.936111	0.407407	0.799210
GOVT	0.472222	0.000926	0.728571
biz*MANU	0.120370	-0.000000	0.710383
capital*MANU	0.197222	0.015741	0.750000

solution coverage: 0.987037
solution consistency: 0.717362

Intermediate Solution
frequency cutoff: 1.000000; consistency cutoff: 0.819149
Assumptions: MANU, BIZ and CAPITAL present.

	raw coverage	unique coverage	consistency
MANU*ip*GOVT	0.137037	0.055556	0.896970
manu*IP*CAPITAL	0.613889	0.174074	0.886364
BIZ*IP*CAPITAL	0.682407	0.226852	0.869104

solution coverage: 0.927778
solution consistency: 0.870547

Appendix 8
Building failure

Table 6: Building failure truth table

CAPITAL	IP	MANU	BIZ	GOVT	number	success	consist
0	0	0	0	0	1	1	1
1	0	0	1	1	1	1	0.866667
0	1	0	1	0	1	0	0.606383
1	0	1	0	1	3	-	0.604982
1	0	1	0	0	2	0	0.585034
1	1	1	1	1	3	0	0.552764
1	1	1	0	1	2	0	0.307054
1	0	1	1	1	3	0	0.29717

Complex Solution
frequency cutoff: 1.000000; consistency cutoff: 0.866667

	raw coverage	unique coverage	consistency
capital*govt*ip*manu*biz	0.146774	0.146774	1.000000
CAPITAL*govt*ip*MANU*BIZ	0.146774	0.146774	0.866667

solution coverage: 0.293548
solution consistency: 0.928571

Parsimonious Solution
frequency cutoff: 1.000000; consistency cutoff: 0.866667

	raw coverage	unique coverage	consistency
govt*ip	0.377419	0.296774	0.883019
govt*manu*BIZ	0.296774	0.216129	0.501362

solution coverage: 0.593548
solution consistency: 0.632302

Intermediate Solution
frequency cutoff: 1.000000; consistency cutoff: 0.866667
Assumptions: MANU (absent) BIZ (absent) CAPITAL (absent)

	raw coverage	unique coverage	consistency
MANU*ip*govt	0.258065	0.185484	0.903955
biz*ip*govt*capital	0.162903	0.090323	1.000000

solution coverage: 0.348387
solution consistency: 0.927039

Appendix 9
Energy success

Table 7: Energy success truth table

CAPITAL	IP	MANU	BIZ	GOVT	number	succes	consist
1	0	1	1	0	1	1	1
1	1	1	1	0	2	1	1
1	0	1	0	0	1	1	0.973684
1	1	1	1	1	3	1	0.753846
0	1	0	1	1	1	0	0.560748
0	0	1	0	1	1	0	0.224719
0	0	0	0	1	1	0	0.19802

Complex Solution
(frequency cutoff: 1.000000, consistency cutoff: 0.753846).

	raw coverage	unique coverage	consistency
CAPITAL*govt*IP*manu	0.235088	0.235088	0.985294
CAPITAL*GOVT*IP*BIZ	0.515789	0.515789	0.821229

solution coverage: 0.750877
solution consistency: 0.866397

Parsimonious Solution
(frequency cutoff: 1.000000 consistency cutoff: 0.753846).

	raw coverage	unique coverage	consistency
CAPITAL	0.840351	0.840351	0.850799

solution coverage: 0.840351
solution consistency: 0.850799

Intermediate Solution
frequency cutoff: 1.000000 consistency cutoff: 0.753846
Assumptions: MANU (present) BIZ (present) CAPITAL (present)

	raw coverage	unique coverage	consistency
manu*IP*CAPITAL	0.501754	0.235088	0.993056
BIZ*IP*GOVT*CAPITAL	0.515789	0.249123	0.821229

solution coverage: 0.750877
solution consistency: 0.866397

Appendix 10
Energy failure

Table 8: Energy Failure Truth Table

CAPITAL	IP	MANU	BIZ	GOVT	number	succes	consist
0	0	1	0	1	1	1	1
0	0	0	0	1	1	1	1
0	1	0	1	1	1	1	0.841122
1	0	1	1	0	1	0	0.666667
1	1	1	1	1	3	0	0.434615
1	0	1	0	0	1	0	0.289474
1	1	1	1	0	2	0	0.243421

Complex Solution (frequency cutoff: 1.000000**,** consistency cutoff: 0.841122).

	raw coverage	unique coverage	consistency
capital*govt*biz*MANU	0.341860	0.341860	1.000000
capital*GOVT*BIZ*MANU*ip	0.209302	0.209302	0.841122

solution coverage: 0.551163
solution consistency: 0.933071

Parsimonious Solution
(frequency cutoff: 1.000000, consistency cutoff: 0.841122).

	raw coverage	unique coverage	consistency
capital	0.804651	0.804651	0.791762

solution coverage: 0.804651
solution consistency: 0.791762

Intermediate Solution
frequency cutoff: 1.000000 consistency cutoff: 0.841122
Assumptions: MANU (absent) BIZ (absent) CAPITAL (absent)

	raw coverage	unique coverage	consistency
ip*MANU*capital	0.472093	0.237209	0.922727
MANU*biz*govt*capital	0.341860	0.106977	1.000000

solution coverage: 0.579070
solution consistency: 0.936090

Appendix 11
Case Studies

What follows is a brief description of our case studies that tries to maintain confidentiality and yet provide a justification for our approach and enough detail to be of interest. Each case study is assigned a letter representing its sector (F, B, and E for Farming, Building, and Energy respectively), and fuzzy scores for each of our five conditions are also given.

Farming

F1

A product of a serial inventor with several small family-oriented companies, one of which undertakes most of the manufacturing with interests in other sectors including ICT and importing. Located in small rural town, husband and wife team with roles of the inventor and administrator respectively, the family has a history of farming in the area although this was ‘barely economic’ towards the end. Innovation began in 1989, a company being formed in 1993. Successive innovations contributed to current model. Considerable networking, training and research undertaken over the course of the innovation, and a website and professionally produced brochures have enabled successful marketing, as do regular appearances at Field days where the product is demonstrated in action.

The business received poor advice regarding IP in the early stages of developing the innovation. Extensive business networking has identified other opportunities which the couple have taken up, including international business partners who are collaborating with two projects.

Variable	Notes	Score
K	$100,000 (self-financed and bank loans)	0.6
G	$75,000 (Regional Development and NZTE funds; collaboration with AgResearch).	1
IP	16 patent applications, 11 granted or filed; two trademarks.	1
M	Most, although some subcontracted out.	0.83
B	Extensive farming networks; importing and distribution rights to several products; collaboration in IT industry.	1
S	Several awards, considerable national and some international sales.	1

F2

From an idea in 2001, this innovation won an award at the National Fieldays several years later. However, sales were not forthcoming: only three were manufactured, all by the inventor himself who works for a local engineering firm. Manufacturing and tinkering takes place in his own workshop after his ‘day’ job. This case study was the first of several that could be classified as the ‘classic’ Kiwi backshed, ‘Number 8 wire’ invention: little financial capital; no help from or engagement with any formal organisations (including intellectual property lawyers or offices); and no formal firm or company structure.

Variable	Notes	Score
K	Little capital investment	0.02
G	No govt support	0
IP	Copyright	0.23
M	All manufacturing undertaken by inventor	1
B	Employed with no other business networks; husband/wife team.	0
S	Only a few ever made.	0

F3

The inventor had previous experience of an innovation that failed, and the husband and wife team now had more experience of process and strategies. Most manufacturing is still undertaken by the inventor himself, although two components are supplied by local firms and assembled by the couple. The inventor's wife has taken on the administration and promotional aspects of this innovation, producing brochures and attending regional fieldays when possible to demonstrate the product. A family member helped construct a website and produce a computer disc for promotion. A top law firm was engaged for patenting and trade marking the innovation.

Some financial support has been won from regional development programmes and government funding, and 'moral' support has come from a semi-formal network of fellow innovators. A concern was that the 12 month period for utilising government funds was too short. Regular sales enable the couple to continue building on their success, and prospects are held for the potential to export.

Variable	Notes	Score
K	Little capital investment of approx. $5,000 (self-financed)	0.04
G	$15,000; contact and support through business mentoring.	1
IP	Trademark and design protection	0.66
M	Most manufacturing, with two other suppliers providing components.	0.67
B	Husband/wife team.	0
S	Regular NZ sales; occasional exports	0.6

F4

The inventor has a background in carpentry and building and also has considerable experience of several different commodity sectors. This particular innovation came about through a problem with previous products. Workplace discussions led to experimentation to produce a prototype; the final design was subsequently achieved with a week's tinkering. An export sale was achieved the first time the innovation was demonstrated. Subsequent actions by a government agency caused concern and seemed to confirm for the inventor the ills of bureaucracy: *She was a bloody nightmare.* Exports sales were also achieved with no formal contract in place despite expensive legal and professional advice that again seemed to needlessly complicate the process.

> *I don't really deal with them because I'm a different brew. I'm a contract worker, I find that they are a bunch of leeches and they are always going to be a bunch of leeches, they are not doers.*

The current business is a family firm, owned by the inventor who has his son running the company which employs 16 to 18 people. The inventor's wife originally "did a fair bit of paperwork". The company does all its own marketing and advertising including a website that "probably needs updating". Several people have tried to copy the innovation including in Australia. While action was undertaken in New Zealand to stop copying, the costs of doing this in Australia, estimated at $80,000, were considered prohibitive. This inventor was fiercely independent, to the point of refusing a government award and cash for complying with a photo-opportunity: "*I don't rely on anyone.*"

Variable	Notes	Score
K	Significant financial investment of approx. $100,000 (self-financed and bank)	0.6
G	No govt. support	0
IP	Patented and two Trade marks	1
M	Most manufacturing undertaken in-house	0.83
B	Extensive business experience in two other sectors; 16-18 employees	1
S	Strong export sales	1

F5

The inventor of this innovation was a fitter and turner by trade beginning in the 1960s, and with experience of innovation dating back to 1979 when he modified an existing piece of technology. Although successful, he did not patent or promote his innovation and subsequently saw the same technology innovation commercialised by a major farm machinery manufacturer.

I didn't know anything about [IP] because I just made things for my own farm.

For this innovation, the inventor was again of the classic Kiwi inventor mould. He made the entire product but struggled to make enough profit to justify the effort. While he investigated taking out IP protection, it was considered too expensive, as was advertising although he persevered with that for some time.

Variable	Notes	Score
K	Little capital investment of approx. $2,000 (self-financed)	0.03
G	No govt support	0
IP	Copyright; further investigations were made but abandoned.	0.23
M	All manufacturing	1
B	Limited business networks	0
S	Limited sales (approx. 50), mainly locally.	0.2

F6

The inventor was the father of the current business owner and came up with the idea and innovation in 1975. All finance and manufacturing was originally contained within the family; manufacturing was now done in China. (A local firm had previously undertaken a key part of manufacture but changed their processes and could no longer provide this service.) Patenting and trade marking were taken care of by a major law firm without problems.

The son now worked fulltime on another business but still devoted efforts to his father invention including scoping North America for export opportunities. Very few others were involved in getting this innovation up and running; few were needed to maintain it now although help was acknowledged as being needed for the US export market.

Variable	Notes	Score
K	Personally financed approx. $10,000	0.06
G	No govt. support	0
IP	Original patent expired; copyright and trademark	0.66
M	Most manufacturing now undertaken in China	0.17
B	One other business operated	1
S	Successful national sales ($500,000/yr)	0.8

F7

The interviewee was a key employee of the actual inventor who just 'wasn't interested' in talking about his work. The original concept was provided by a farmer who personally approached the inventor about ten years ago; the innovation itself has only been on the market about 5 years. Although IP was not originally secured, an IP lawyer has since been engaged.

He's got a damn good attorney, patent attorney, so that's how we try to kick arse. Yes he knows he should have done it [earlier]!

With several other firms interlinked, the inventor has extensive business networks to draw on, based in a small rural town within a strong dairying region. The inventor's own businesses are able to undertake most of the manufacturing processes, with just one component and one process outsourced. The firm also does all its own marketing including website and brochures. Strong sales have been achieved, particularly in the North Island but the product has been successfully exported to Australia although the personal sales pitch was seen as vital: “When I’m there they sell, when I’m not there they don’t move”.

Variable	Notes	Score
K	Self-financed, approx. $100,000	0.6
G	No govt. support	0
IP	Trademarked; several patents, designs etc held in other companies	0.97
M	Extensive manufacturing capacity	0.83
B	Extensive business networks	1
S	Strong national and international sales	1

F8

This innovation dates back 20 years and is now owned and promoted by the inventor’s daughter and granddaughter. Based in a relatively isolated farming community, the product was self-financed with no government support, manufacturing being undertaken by a firm in the nearest city, approximately 250 km. distant. Family members undertook some assembly. Possessing excellent practical skills, the inventor had good links through the local and regional farming and hunting communities, including contacts with old WW2 comrades. He was very independent:

There was only one way of doing it and that was his way.

Regular sales are made through fieldays although the costs for the Mystery Creek Fieldays were considered too expensive (citing $3,000). It has proven difficult to maintain links with retailers such as stock agents although some regular orders are still made. Some product has been exported to the UK although not to the degree that would enable a score of ‘1’ for Success.

Variable	Notes	Score
K	Little funding	0.03
G	No govt. support	0
IP	Patent expired	0.23
M	Local manufacturing utilised; some self-assembly	0.33
B	Good links through farming and family, building on previous innovation experience with study.	1
S	Regular sales through fieldays; very limited exports to UK.	0.8

F9

An invention essentially concerned with animal welfare, by an inventor that loved animals that has struggled to ‘take off’ due to the indifference of the target market. There was media promotion with a number of articles being written when it first released, and a black and white pamphlet and colour brochure being produced, but it has only achieved limited distribution through personal contacts.

Variable	Notes	Score
K	Limited funding	0.03
G	No govt. support	0
IP	Copyright	0.57
M	Local manufacturing utilised	0.33
B	Links limited to farming.	0
S	Struggling sales; not supported by key market	0.2

F10

An invention from a ‘passionate’ farmer who has set about refining and promoting his invention with quiet dedication. Self-financed from an overdraft facility as well as selling shares, the innovation is now protected by a separate trust from the farm itself. Some support has been accessed from a regional development agency, including mentoring although that was not considered usefully. A strong local supporter with engineering skills and networks was credited with help: “He’s been fantastic, he hasn’t charged one cent for his time or his advice or anything”. IP in the form of patents and trademarks have been secured.

Manufacturing was originally by a Wellington firm; the product is now made in Auckland although at the time of the interview the inventor had concerns about the quality of the finish. The inventor enjoys good business networks through involvement in a previous innovation (which failed), and a farming partnership with a family member and comprising several farms in total.

Variable	Notes	Score
K	Self-financed, approx. $50,000	0.52
G	Regional development agency support (mentoring)	1
IP	Two patents (one expired) and Trademark	0.94
M	Inventor made early prototypes; now made by Auckland firm	0.17
B	Good industry and regional contacts including other business activities that include previous innovation experience	1
S	Some sales made and advance orders received; inquiry from US	0.6

F11

A unique invention that has helped the inventor’s business remains profitable in a competitive market where he needed to cut costs as a ‘necessity’, ‘to stay in the game’. The inventor worked primarily alone, accessing some engineering from a local firm, and was self-financed from his own business, using about $350,000. He refused to patent the invention, in fact would be happy for it to be copied if it helped others in his situation stay in business:

If anyone in New Zealand wants to know how to make it,
I’ll tell them!

The inventor has profited from a previous innovation in the farming sector which he first patented worldwide before selling the patents.

Variable	Notes	Score
K	Self-financed from own business, approx. $350,000	0.88
G	No govt. help sought	0
IP	Copyright (Has previous experience of IP)	0.23
M	Most manufacturing done by inventor	0.83
B	Also agent for import business	1
S	A one-off innovation that works for the purpose it was designed	0.2

F12

A software package that was first developed in the early 1990s at a university and has been undergoing regular improvements and upgrades ever since, this innovation has now expanded beyond its immediate target market and has secured considerable private capital for future development. No government help has been accessed but as the innovation originated within the NZ university system, the case is not scored as non-membership; rather it is scored as having minimal government support. No patent has been taken out, instead the company relies on secrecy and complexity and ongoing improvements to protect their IP.

All development takes place within the company with two employees offering feedback and ideas; considerable useful feedback comes from end-users. The original inventor has considerable networks and an investment partner brings a wider network of business networks that have aided expansion of the market. Strong sales have been achieved in the original target market of farmers, and sales are growing from the greater opportunities now evident.

Variable	Notes	Score
K	Private investment capital of $1,000,000	1
G	Originated within public university environment	1
IP	Trademarked; IP further 'secured' by complexity and secrecy	0.66
M	All development takes place in-house	1
B	Considerable business networks from inventor and investment partner	1
S	Strong sales in original target market; growing sales from widening market	0.8

F13

A quirky case study, one of the few in which the inventor is female, this innovation is essentially a home-built solution to a simple problem. Now farming, the woman has had wide work experience after originally growing up on her parents' farm. No financial investment has been made in the innovation, no support was sought or needed, IP was not relevant, eliciting the comment that:

That would be selfish.

Only one prototype of this invention exists but it has been 'used by the neighbours'.

Variable	Notes	Score
K	No costs	0.02
G	No govt support	0
IP	No IP	0.03
M	Made at home with other components for home farm use.	0.67
B	Limited farming networks	0
S	No sales	0

F14

A similar case to F2, F3 and F5, the inventor is a fitter and turner working for a small firm in a farming district. He came up with the idea, designed and manufactured all the products to be sold, and sold about 50 regionally. No outside support was sought except for advice on IP which consisted of 'writing the idea on a letter and posting it to myself'.

Variable	Notes	Score
K	Minimal capital invested in development	0.03
G	No govt support	0
IP	No IP	0.23
M	Copyright	1
B	Employment as tradesman the sole business activity	0
S	Limited regional sales	0.2

F15

A similar product to F1, and also the result of a husband/wife farming 'team'. The invention originated when the husband sought to improve a particular process with stock handling; the innovation came about when a farm visitor in 1994 commented on the cleverness and wider applicability of the prototype. A Fieldays demonstration quickly followed and a few units were made and sold although sales were flat until about 2002 when sales showed a rapid growth.

Some government help has been sought over time. Free mentoring advice available through a regional initiative was well received; interactions over applications for funding have been unsatisfactory. Most manufacturing is done in house with staff being hired as demand requires. The recession has hit this innovation hard, halting a major push into the Australian market and at the time of the interview the couple were considering laying off more staff.

Variable	Notes	Score
K	Self-financed, approx. $100,000	0.6
G	$5,000 grant; business mentoring	1
IP	Copyright, patent, trademark	0.66
M	Undertakes most manufacturing	0.83
B	Husband/wife team access various business opportunities	1
S	Strong national sales	0.8

F16

An innovation from a ‘natural’ inventor who has come up with several other agricultural-focused innovations. For this particular innovation he devoted 40 days ongoing experimentation but hasn’t sought to commercialise the result. The inventor has been able to access advice from one experienced technology practitioner in his region, and finds the region supportive of innovation in general.

A research institute was approached through a personal contact which enabled a limited collaboration for independent assessment of the innovations specifications.

Variable	Notes	Score
K	Approx. $20,000 estimated costs	0.14
G	Government grant	1
IP	Copyright	0.23
M	Undertakes significant degree of manufacturing	0.83
B	Good regional networks; widening contacts through innovation	1
S	Sales not sought	0.2

Building

B1

The outcome of an insight from the inventor who was a tradesman and with his trade skills and trial and error approach has developed a system of home heating. The prototype was installed in his own house over two decades ago, with ongoing refinements. A family business now owns and operates all aspects of the innovation including advertising and a website. Franchising was tried several years ago but failed through quality control issues. Three patents and a trademark have been granted but are viewed as ‘useless’ as they require expensive legal action to actually defend. The inventor has some networks through his work but has relied a lot on word of mouth and a website – developed by his daughter - for promotion. A second system has been developed and has become a second business.

Variable	Notes	Score
K	$100,000	0.6
G	No support	0
IP	Three patents and a trademark	0.97
M	All installation but reliant on suppliers for most components	0.67
B	Two interconnected business operated	1
S	Strong national sales	0.8

B2

The invention of one of the few female inventors interviewed, who had to juggle a young family as a solo mum for much of the early days of this innovation. While learning many different aspects of the building trade, this inventor also went back to school to learn subjects needed for higher professional qualifications. Construction is undertaken by licensees and accredited specialists. Regular awards, word-of-mouth, appearances at relevant building shows, and a well-maintained website – including the history and ongoing developments of the building system - have helped achieve strong nationwide sales.		
Variable	Notes	Score
K	$250,000	0.8
G	Grant from regional development agency	1
IP	Patent 'voided pre-acceptance'; two Trademarks held	0.79
M	Involvement in manufacturing now limited	0.17
B	Sole business	0
S	Good and ongoing nationwide sales	0.8

B3

This innovation came about as a response to the 'leaky building' syndrome in the NZ residential sector where the inventor has been working as a specialist for several years. Self-financed to almost $1.5m with a business partner and close associate, the partnership has a wide product range but is yet to realise significant returns. All products are now manufactured by a single specialist firm in the North Island. As with others interviewed in the building sector, government and its agencies are seen to be major obstacles: *…what they are saying is, like everybody does, the law is some infallible bloody fountain of wisdom and knowledge!*		
Variable	Notes	Score
K	Self-financed with a business partner	1
G	No govt assistance	0
IP	Three patents, all abandoned	0.94
M	Manufactured in North Island	0
B	Extensive business and consultancy networks	1
S	Limited sales	0.5

B4

An invention that has been inspired by overseas products, especially in North America, that has aspects of a traditional craft. It has been self-financed with considerable investments in time and travel costs by the inventor. The associated business was owned in partnership with another couple, an arrangement that did not prove satisfactory and at the time of the interview was in the process of being restructured. A wide array of professional relationships is maintained. The inventor has had very positive initial interactions with a regional business mentoring scheme and is a member of trade associations which provides useful contacts. A good relationship also is maintained with a mentor at a university where trials are underway on one use of the product.		
Variable	Notes	Score
K	Significant start up and ongoing costs	0.67
G	Regional mentoring scheme; university links	1
IP	Trademarks	0.66
M	Able to undertake most manufacturing	0.83

B	Good professional and personal networks	1
S	Regular sales being made; slowly expanding	0.6

B5

A radical building design that has originated with the inventor musing upon a personal problem about a decade earlier that has evolved into a highly designed technical achievement. The inventor has a design background and has accessed extensive business networks, including venture capital.

Both the inventor and a colleague expressed frustration at the policies and practices of regional councils and BRANZ. With two patents on this innovation, the inventor also has several trademarks. In working through a Chinese manufacturer, he has admitted some IP will be stolen but accepts that as one of the costs of working there and at the time of the interview he was attempting to gain an interest in another factory to not only mitigate IP risks but to access more advanced facilities. Several show homes in key locations, brochures, networking, word-of-mouth, and a website have helped build national sales, and international sales are growing. (Australian market may be given over through a licensing arrangement with a previous business partner).

Variable	Notes	Score
K	Considerable finance accessed	1
G	NZTE support	1
IP	Two patents and several trademarks	1
M	Manufactured in China	0
B	Extensive business activities and links	1
S	Good sales in national market; growing international sales	1

B6

This case is an insulating product made from a recycled waste product. Very little financing has been involved with the inventor coming up with cheap alternatives and self designed and built machinery to enable production. While the innovation is regularly featured in regional sustainability debate, the inventor is strongly focused on making a successful business case first and foremost
Strong local ties were involved. Employees were often sourced from local work schemes, and the business operated in collaboration with the local city council.

Variable	Notes	Score
K	Limited financial capital	0.06
G	Strong local council support	1
IP	Copyright; experience with IP accumulated on previous innovation	0.23
M	Manufacturing and installation skills all in-house	1
B	Sole business	0
S	Strong regional sales	0.6

B7

An innovation that has sat with the inventor, a professional with a wide range of interests including the creative arts, and is designed to provide the owners of a structure the ability to take it apart and reassemble it on another site.

Variable	Notes	Score
K	Significant accumulated costs	0.56
G	No govt sought	0
IP	Operates with Creative Commons open access; has previous patent experience	0.03

M	Works closely with an associate	0.83
B	Several business and personal interests ongoing	1
S	Prototype erected	0.2

B8

The inventor has over 40 years experience in the building industry and has been trying to promote his simple innovation for about 4 years and at least $100,000 investment. No government assistance has been sought, and BRANZ is seen as part of the problem of innovation in the building sector. Basic patenting and trade marking have been done through an independent IP lawyer.

This inventor expressed a strong patriotic approach to manufacturing: *I get them made in Auckland because I refused to get them made in China, I wouldn't do it there I prefer it to be a New Zealander and I would obviously cut my profit to do that.*

Sales had been very limited and the inventor had to decide have much more time, effort and money to invest.

Variable	Notes	Score
K	Self-financed, approx. $100,000	0.6
G	No govt assistance	0
IP	NZ and Australian patents; Trademarked	0.88
M	Manufactured in Auckland	0
B	Well networked through the building sector as well as instigating several projects in other areas.	1
S	Few sales	0.4

B9

This innovation dates back over 15 years, the current business partners being his daughter and son-in-law. While self-financed originally, strong commercial partnerships have been in place for several years The company employs ten people but struggles to find qualified staff, possibly due to being located somewhat outside a main population centre. The inventor did not follow up IP issues in the first stages of innovation and this was proving an issue to be resolved for the continuing expansion of the business.
Raw materials and some manufacturing were done within the region. An additional innovation was with one part of the manufacturing process and this was patented. The son-in-law had excellent networks that included a mentor who was CEO of a significant industry leader.

Variable	Notes	Score
K	Corporate partnerships	1
G	No govt assistance	0
IP	NZ and international patents; one Trademark	0.88
M	Most manufacturing done within purpose-built factory	0.83
B	Good industry links through commercial relationships; also benefits from a well-placed mentor	1
S	Strong national sales	0.8

B10

This case was an invention by a tradesman who, in his words, "was struck by these bright bucks …coming along finding these little areas in the building industry and making money out of it and I was sitting there nailing nails in thinking I should be able to get some part of that …". Asking the advice of friends and colleagues along the way, he has successfully dealt with marketing and compliance issues. The inventor's wife contributes through significant experience in finances.

The recession at the time of the interview (2009) had severely negatively affected sales but there was hope of an increase in sales.

Variable	Notes	Score
K	Self-financed, approx. $200,000	0.74
G	No govt support (but support is now being sought)	0
IP	Trademark and several registered designs, including in Australia	0.88
M	Manufactured by a local firm	0
B	Limited trade networks	0
S	Sales slumped with recession but picking up	0.6

B11

This innovation is developed by a tradesman who has come up with several products in the building sector. This particular product came from an idea for a novel aid for builders about 10 years ago. Discovering a US patent very similar to his concept, he personally negotiated its purchase. After building a prototype and getting positive feedback, he then sought local manufacturer. Difficulties have arisen over fine-tuning the products as two key people left the firm:

After 18 months and quite a lot of money I said well I know what works, what I had to start with, so we are going to do it this way now and that's when we started to make a bit of progress.

A distributor had just been contracted. A key stumbling block was the non-alliance with the Australian market and difficulties in accessing the US, where he has imported new products from before.

Variable	Notes	Score
K	Self-financed approx. $250,000	0.8
G	No govt assistance sought	0
IP	NZ, Australian and US patents	0.88
M	Initial prototypes built but manufacturing primarily done by small engineering firm	0.33
B	Trade networks; growing innovation links	0
S	Some sales but struggling to expand nationwide and to export	0.6

B12

This innovation originated with an experienced builder who adapted a process for a different product and has found it outperforms comparable products. Significant investments in machinery, time and money have been made and good regional sales have been achieved, with national sales strengthening. No government assistance has been sought, and one patent and a trademark have been secured; the inventor's wife has been a significant force behind administrative and promotional efforts.

At this stage all manufacturing is in-house but increasing demand will challenge the scale the operation is working at.

Variable	Notes	Score
K	Major financial investment	0.97
G	No govt. assistance	0
IP	One patent and one trade mark	0.66
M	All manufacturing in-house	1

B	Wider industry business interests	1
S	Growing national sales	0.8

B13

From an idea to successful launch in just three years, this product underwent considerable investigation by/with a regional development organisation and provided $50,000 funding. One of the conclusions of the report being it would have to be manufactured in China. Self-financed with $60,000, family members subsequently invested up to an additional $40,000. A brother-in-law of the inventor has worked in marketing efforts, including arranging for manufacturing in China and researching markets in North America and Europe. A New Zealand distributor based in Auckland has been selected, as has an Australian distributor.

The inventor, who is a tradesman himself, has found his fellow tradesmen slow to take up new ideas. However, considerable promotion has occurred through innovation and trade magazines, as well as a well-designed website. This inventor keeps up-to-date with relevant developments and as he says: "*I'm in the best laboratory ever!*"

Variable	Notes	Score
K	Approx. $100,000, self-financed and family investment	0.74
G	Regional development organisation	1
IP	Four patents and a trademark	0.99
M	Made in China	0
B	Wider business engagement	1
S	Expanding national sales with prospects for exports	0.8

B14

This innovation is a simple aid to minimise the physical effort builders exert in a repetitive labour-intensive process. Despite its simplicity, this innovation has struggled to gain recognition and sales. No assistance was sought from government organisations, and the inventor had limited business networks to access information, advice, and mentoring.

Variable	Notes	Score
K	Minimal investment	0.06
G	No government or regional support sought	0
IP	Patented	0.23
M	Some manufacturing undertaken	0.33
B	Tradesman	0
S	Poor sales	0.2

B15

This case is also a simple innovation to aid trades people in a repetitive, labour-intensive aspect of their work. While coming up with other inventions for his own business, this is the first invention he's commercialised. Self-financed (including through the sale of his house), this innovator has successfully pulled together all the various components of an innovation project and is now in the position of advising other NZ inventors as well as importing other trade-related products. Other expertise is contracted: manufacturing, packaging, promotional material (including a website with embedded video), and patent advice.

The inventor contacted NZTE but was not successful. Exhibiting at a US trade show enabled a large number of useful contacts in the US market that, at the time of the interview, were being 'whittled down' to a potential partner.

It's like a snowball. It just gets bigger and bigger as it goes along…once you start, you've got to keep going.

Variable	Notes	Score
K	Self-financed (incl. sale of house and income from business), approx. $200,000	0.74
G	Unsuccessful request to for funding	0
IP	Early interactions with patent attorney	1
M	Manufactured	0
B	Original business maintained while new business established. Extensive networks, including international partners, established	1
S	Good sales, nation market beginning to improve	0.8

B16

This innovation came about through an attempt to systematise residential housing construction. The current business is run by the son of the inventor, who had a long history of self-employment and business start-ups. Some market research has been done for Australia, and plans exist for expansion into the UK.

Variable	Notes	Score
K	Financed through family firm	1
G	Support from NZTE	1
IP	Have concentrated on trademarks (4)	0.97
M	Mainly in-house	0.67
B	Other businesses in building sector; nation-wide licensed dealerships	1
S	Strong national sales.	0.8

B17

This potentially radical innovation has involved significant research over a period of 12 years. Attempts to collaborate with other companies, including international, has been difficult, although now fruitful discussions have led to a point where progress is being made. Plans to manufacture in a regional locality have been stymied through port access issues.

This case is one of three case studies scored 0.5 for success at it is very much a work-in-progress and is currently said to be at the point of take-off with negotiations between several major companies.

Variable	Notes	Score
K	Significant investment, approx. $1.6 million	1
G	Assistance from NZTE and a university researcher.	1
IP	One patent, trademarks	0.66
M	Primarily in-house; several key inputs imported.	0.83
B	Other businesses	1
S	Possibly at point of take-off	0.5

Energy

E1

The innovation by a trained professional in one field who conceived of a novel heating water method, this invention was only intended for family use. Positive responses from friends and contacts saw the project take off as an innovation. It is now being exported.

This case study seems to have captivated the imagination of several key people including the inventor's bank manager and NZTE staff.

Variable	Notes	Score
K	Primarily self-financed	0.55
G	$15,000 + $5,000 reimbursement from NZTE; strong regional support	1
IP	Copyright and patent; previous IP experience	0.66

M	Limited; most contracted out with strong reliance on contractors for most components	0.17
B	Pre-existing professional network; strong links through proactive networking and alternative business activity	1
S	Growing national and international sales	1

E2

This case study originated with a family farming venture but is classified as an energy innovation due to the character of the invention itself. The innovation is controlled by a father/son partnership. Manufacturing was originally by a local firm but has since moved to the Australia branch.

Having achieved very good national sales within the farming sector (particularly with dairy farmers), the product has consistently struggled over several years to get recognition beyond farming, despite high performance specifications and obvious wider application.

Variable	Notes	Score
K	Self-financed through farming business, approx. $200,000	0.74
G	Some interaction but no support	0
IP	Strong NZ and international IP protection	0.98
M	Now manufactured by Australian firm	0
B	Limited to farming sector and some engineering circles	0
S	Very good national sales	0.8

E3

This case study is one of the larger-scale innovations investigated with the product weighing up to thirty tonnes and about a million dollars spent on R&D. Manufacturing is solely in-house, with employees building machines as their schedules suit. It is planned to eventually contract out most manufacturing, with Europe being the preferred location due to the skills base and potential market.

The original inventor has passed some control, especially marketing and financing, to a contracted staff member who has an extensive NZ and international business background. This person expressed concerns over the lack of coordination in NZ's innovation and energy policies.

Variable	Notes	Score
K	Self-financed; venture capital being sought	1
G	Awarded $70,000 FRST funding; minor collaboration with a university	1
IP	Extensive domestic and international IP coverage	1
M	Currently solely in-house	1
B	Extensive national and growing international connections	1
S	Slow but growing sales	0.6

E4

This case study represents one invention by a serial inventor, a qualified engineer who lived in an isolated rural area and worked repairing and maintaining large-scale equipment. Collaboration was sought with a university laboratory for testing but this relationship did not formalise and has since ended. Several patents pertaining to other inventions have been lodged and 'voided pre-acceptance'.

Variable	Notes	Score
K	Self-financed	0.2
G	No government help sought	0

IP	Several lapsed patents Regular interaction with IP area;	0.66
M	Inventor undertakes all manufacturing	1
B	Good networks through engineering specialty; otherwise limited	0
S	No sales and little interest	0.2

E5

This innovation comprises a home-heating system that has struggled for a small market share but sales are increasing. Most customers are non-NZers, considered by the (North American immigrant) inventor to reflect a certain attitude:

NZers I think like to live like Third World country people in winter. In fact they wear it like a badge of honour, that you only live in one room you don't have to heat the rest of the house.

Variable	Notes	Score
K	Self-financed	0.6
G	No government support	0
IP	Patent pending	0.88
M	Essentially now providing plans; supply of various components contracted, including offshore suppliers	0.17
B	Several varied business interests, including offshore	1
S	Regular if slow uptake	0.6

E6

This innovation came about through an ongoing collaboration in a university that began in 1981 with a strong philosophy towards supporting energy supply to isolated communities in the developing world: "Purely altruistic" as one of the inventors said.

Variable	Notes	Score
K	Limited finance available	0.2
G	Some NZTE aid; considerable use of publicly-funded university resources	1
IP	No IP sought	0.03
M	Mainly built by inventors	0.67
B	Other businesses involving innovation very successful; good research networks; wide contacts in innovation circles	1
S	No sales	0.2

E7

This very successful innovation has rapidly achieved great publicity and growing international interest through its technical qualities. The product has been developed by an engineer who has invested considerable time and capital. With two partners the business has evolved around his invention and has won a significant award and benefitted greatly from the associated media coverage.
Good support was received from the local regional innovation organisation as well as EECA.

Variable	Notes	Score
K	Self-financed and business partners	0.98
G	Regional and EECA support	1
IP	Patented and trademarked; previous IP experience	0.66
M	Most manufacturing done by subsidiary	0.83
B	Wide industry and innovation networks through business associates	1
S	Strong national sales; opportunity to export	0.8

E8

A design concept without any prototype, this invention has had minimal investment and support. Essentially a small collaborative project between university researchers, the key researcher having retired.

A realism, common to all energy innovators, was expressed: "*Economics, that's everything. If you can't match the price then forget it and so it would be a case of making it, it's got to be very simple…*"

Variable	Notes	Score
K	Very little financial support	0.02
G	No government support	0
IP	Copyright	0.23
M	Limited to drawings and models	0.67
B	Limited to specialised research network	0
S	Concept and model only	0

E9

An invention that came about through a serial inventor and expert in one field who applied his skills to an area of personal interest to come up with a technological fix in response to regional environmental strategies that were going to limit personal home heating options. A strong background in electronics, including several innovations and patents, this innovator lobbied local and regional government officials over time to argue his case, all the while perfecting his innovation.

I've always wanted to be on the cutting edge of new technology.

A FRST grant of $90,000 was received 'late in the day'. The inventor has nothing to do with manufacture or sales and is now working on, among other things, a wind turbine.

Variable	Notes	Score
K	Self-financed, approx. $100,000	0.6
G	FRST grant $90,000	1
IP	One patent	0.88
M	All contracted out.	0
B	Other businesses	1
S	Strong sales	1

E10

An outcome of three colleagues with an engineering background, collaborating on a sustainable energy project that is well-developed if not yet commercially strong. Manufacturing is at the prototype stage with significant collaboration from various local suppliers, some of whom have had to innovate themselves to solve various problems.

Variable	Notes	Score
K	Approximately $150,000 invested	0.74
G	Government and regional development grants received	1
IP	Three patents, (one international, one voided pre-acceptance)	0.79
M	Mainly in-house	0.83
B	Several other business engagements	1
S	One the verge of commercial release	0.5

Appendix 12
NZ Technology Innovation Statistics: Change in Technology in New Zealand Businesses

	Total number of businesses(2)		Degree of technological change							
			Not at all		To a minor degree		To a major degree		Completely	
			2007	2008	2007	2008	2007	2008	2007	2008
	2007	2008	Percent(3)							
Business size										
6–19 employees	26,316	26,538	40	43	51	48	5	5	0	0
20–49 employees	6,342	6,270	32	35	60	58	7	5	0	0
50–99 employees	1,758	1,779	23	24	64	66	11	7	1	0
100+ employees	1,467	1,485	18	20	71	70	9	9	0	0
Industry										
Agriculture, forestry and fishing	3,042	3,039	41	46	53	47	3	4	0	0
Mining	99	105	30	37	61	60	6	0	0	0
Manufacturing	5,442	5,343	35	39	56	54	7	6	0	0
Elect., gas, water, waste services(4)	102	105	32	34	62	57	6	9	0	0
Construction	3,693	3,786	40	45	51	44	2	5	1	0
Wholesale trade	2,961	2,955	28	32	59	59	12	6	0	0
Retail trade	4,437	4,335	38	43	51	50	5	2	0	0
Accommodation and food services	3,975	4,140	58	58	38	36	2	2	0	0
Transport, postal and warehousing	1,440	1,419	36	38	60	54	4	5	0	0
Information media and telecommunications	357	357	20	20	64	65	14	13	1	0
Financial and insurance services	582	552	23	26	61	62	12	12	1	0
Rental, hiring and real estate services	945	954	27	35	60	55	7	7	2	0
Professional, scientific and technical services	3,393	3,501	26	22	61	66	12	11	0	0
Administrative and support services	1,332	1,374	37	41	50	49	8	7	0	2
Education and training	645	645	36	27	56	60	6	11	0	1
Health care and social assistance	1,953	1,944	30	35	65	58	3	4	1	0
Arts and recreation services	444	474	32	42	58	51	4	4	1	0
Other services	1,032	1,044	36	44	53	46	6	6	0	1
Overall	**35,883**	**36,075**	**37**	**40**	**54**	**51**	**6**	**5**	**0**	**0**

(1) This refers to the last financial year as at August of each collection period.
(2) For more information on the businesses included, refer to the technical notes of this release.
(3) Percentages are of all New Zealand businesses in each business size or industry category.
(4) Results for the electricity, gas, water and waste services industry should be treated with caution due to the small number of businesses in this category.

Source: http://www.stats.govt.nz/NR/rdonlyres/EF8F17B1-76C0-4F9D-8AB949CBEC5F4A52/41217/BusinessOperationsSurvey2008AllTables1.xls

Appendix 13
New Zealand technology innovation statistics: comparison with best commonly available technology

	Total number of businesses		Core equipment comparison							
			Fully up-to-date		Up to 4 years behind		Up to 10 years behind		More than 10 years behind	
			2007	2008	2007	2008	2007	2008	2007	2008
	2007	2008	Percent							
Business size										
6–19 employees	26,316	26,538	51	48	23	27	5	5	2	2
20–49 employees	6,342	6,270	54	51	25	28	5	6	2	2
50–99 employees	1,758	1,779	54	51	27	27	6	6	2	2
100+ employees	1,467	1,485	46	46	33	33	8	8	3	2
Industry										
Agriculture, forestry and fishing	3,042	3,039	45	47	29	23	7	8	4	2
Mining	99	105	52	43	24	26	9	14	6	3
Manufacturing	5,442	5,343	35	33	30	31	13	14	5	5
Elect., gas, water, waste services	102	105	50	46	24	26	12	9	0	3
Construction	3,693	3,786	69	63	9	18	0	0	0	1
Wholesale trade	2,961	2,955	49	39	25	32	5	5	2	2
Retail trade	4,437	4,335	52	47	20	20	4	7	1	2
Accommodation and food services	3,975	4,140	44	40	25	37	8	6	1	3
Transport, postal and warehousing	1,440	1,419	48	49	28	32	12	6	4	0
Information media and telecommunications	357	357	59	54	29	34	5	3	1	1
Financial and insurance services	582	552	56	56	26	28	2	3	1	1
Rental, hiring and real estate services	945	954	52	60	28	26	3	2	1	0
Professional, scientific, technical services	3,393	3,501	67	63	27	30	2	0	0	0
Administrative and support services	1,332	1,374	53	53	29	27	5	3	0	0
Education and training	645	645	62	63	28	21	1	0	0	0
Health care and social assistance	1,953	1,944	67	61	18	24	0	1	0	0
Arts and recreation services	444	474	49	38	23	32	1	7	3	2
Other services	1,032	1,044	48	53	28	26	4	5	0	1
Overall	**35,883**	**36,075**	**52**	**49**	**24**	**27**	**6**	**6**	**2**	**2**

Source: http://www.stats.govt.nz/NR/rdonlyres/EF8F17B1-76C0-4F9D-8AB9 49CBEC5F4A52/41217/BusinessOperationsSurvey2008AllTables1.xls

RESEARCH REPORTS:

289 **Nanotechnology – Ethical and Social Issues: Results from a New Zealand Survey**
Cook, Andrew and Fairweather, John 2006

290 **Single Farm Payment in the European Union and its Implications on New Zealand Dairy and Beef Trade**
Kogler, Klaus 2006

291 **Organic Certification Systems and Farmers' Livelihoods in New Zealand**
Herberg, L.A. 2007

292 **Operations at Risk: 2006: Findings from a Survey of Enterprise Risk in Australia and New Zealand**
Smallman, Clive 2007

293 **Growing Organically? Human Networks and the Quest to Expand Organic Agriculture in New Zealand**
Reider, Rebecca 2007

294 **EU Positions in WTO Impact on the EU, New Zealand and Australian Livestock Sectors**
Santiago Albuquerque, J.D. and Saunders, C.S. 2007

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